Multi-User Droplet Combustion Apparatus Interface Control Document

Fluids and Combustion Facility

Rev. C
May 10, 2005

AUTHORIZED by CM when under FORMAL Configuration Control	
Date	Signature
9/2/05	*/s/ Nancy S. Guzay*

Availability:

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National Aeronautics and Space Administration
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FOREWORD

This document is under the Configuration Management (CM) of the Microgravity Research, Development, and Operations Contract (MRDOC) Control Board; however, any changes or revisions to the baseline version must be approved by the Exploration Systems Division (ESD) Control Board Chair.

Approved By: /s/ *Stephen N. Simons* **Date:** 8/25/05

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PREFACE

The FCF is being developed under the MRDOC, through sponsorship of the National Aeronautics and Space Administration (NASA) John H. Glenn Research Center (GRC). The FCF Team is developing a modular, multi-user experimentation facility for conducting fluid physics and combustion science experiments in the microgravity environment of the International Space Station (ISS). The FCF consists of two laboratory facilities: the Fluids Integrated Rack (FIR), and the Combustion Integrated Rack (CIR). Also included in MRDOC are the required support efforts for Mission Integration and Operations, consisting of the Telescience Support Center (TSC) and FCF Utilization Team.

The payload-unique Interface Control Document (ICD) is the primary technical agreement between the Payload Developer (PD) of the Multi-User Droplet Combustion Apparatus (MDCA) and the Fluids and Combustion Facility (FCF) Utilization Team. The abbreviations and acronyms list is found in APPENDIX A . The MDCA Exceptions are found in APPENDIX B . The list of items To Be Determined (TBD) is found in APPENDIX C .

The MDCA, which operates within the CIR, is a modular, multi-user experimentation mini-facility for conducting droplet combustion science experiments in the microgravity environment of the ISS. The MDCA is being developed under the MRDOC, through sponsorship of NASA and GRC.

SIGNATURE PAGE

MULTI-USER DROPLET COMBUSTION APPARATUS INTERFACE CONTROL DOCUMENT FOR THE FLUIDS AND COMBUSTION FACILITY

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INTERFACE CONTROL DOCUMENT
FOR THE
FLUIDS AND COMBUSTION FACILITY**

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REVISION PAGE

MULTI-USER DROPLET COMBUSTION APPARATUS INTERFACE CONTROL DOCUMENT FOR THE FLUIDS AND COMBUSTION FACILITY

Revision	Date	Description of Change and ECOs Incorporated	Contractor Verification and Date	NASA Verification and Date*
Preliminary	12/13/00	Initial Release	12/20/00	
Rev 1	5/18/01	Updated Sections 1.0 through 1.4 to reflect current information Added Section 1.5 CIR System Description and Capabilities and subsections Updated Section 2.0 and subsections Updated Sections 3.0 through 15.0 (and subsections) to reflect current interface requirement information Added Appendix for Exceptions Resolved the following TBD's: 01-01, 01-02, 01-05, 01-06; 02- 0103-01, 03-08 through 03-1604-01 through 04-04, 04-13, 04-1405-02, 05-04 through 05-49; 06-01 through 06-0907-01 through 07-06; 08-01 through 08-0409-01 through 09-18; 11-01 through 11-0315-01 through 15-45; B-01 Added the following TBD's: 01-07 through 01-12; 03-17 through 03-1904-18 through 04-61; 05-5010-01	05/22/01	
Rev. 2	07/25/02	Preliminary review copy		
Final	08/23/02	Superseding CIR-ICD-0106 Rev. 1 in its entirety		
Final	10/31/02	Includes updates and signatures to Final submit	10/28/02	01/06/03
A	04/25/03	Updated entire document to reflect changes to the CIR design. ECO number FCF-ECO-0271.	05/01/03	05/08/03

Revision	Date	Description of Change and ECOs Incorporated	Contractor Verification and Date	NASA Verification and Date*
B	12/02/03	Updates based on FCF-IDD-CIR Rev. A. Command and Data Handling section 8.0 completely re-written. MDCA Applicability Matrix table updated. ECO number FCF-ECO-0658 incorporated.	12/03/03	12/18/03
C	05/10/05	Incorporates DCN-6938	07/21/05	08/25/05

*Enter “**N/A**” if NASA approval is not required by contract.

CONTACT LIST

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1.0 INTRODUCTION

1.1 Purpose

This ICD is the primary technical agreement between the PD of the MDCA and the FCF Utilization Team.

This ICD defines all applicable interfaces developed for the payload. It has an applicability table for requirements stated in FCF-IDD-CIR, together with descriptions of payload-unique hardware and software needs. The interface requirements and definitions described in this ICD shall be verified in accordance with the Payload Verification Plan (PVP). The FCF-PVP-CIR-MDCA is developed based on the CIR Generic Payload Verification Plan (GPVP), FCF-GPVP-CIR. The GPVP defines the verification methodology and data requirements for verifying each of the requirements in FCF-IDD-CIR but does not impose any additional requirements. Verifications completed by the PD in accordance with the PVP will be rolled up with other CIR verifications for presentation to the ISS and the Johnson Space Center (JSC) Payload Safety Review Panel.

1.1.1 Definition of Payload-Unique Interface Control Document

A. Identifies the Interface Definition Document (IDD) interfaces and requirements that apply to a payload.
B. Identifies the payload-unique interfaces.
C. Defines and controls the use of the defined interfaces by the PD.
D. Establishes commonality with respect to analytical approaches, analytical models, technical data, and definitions for integrated analysis by the PD and the FCF Utilization Team.

1.1.2 Exceptions to IDD Requirements

Any exception from the requirements defined in FCF-IDD-CIR shall be documented using form MRD-FRM-0139 per MRD-PRC-0137. All approved exceptions will be documented in APPENDIX B of this ICD. Exceptions shall document the specific requirement that could not be met and a rationale for acceptance. The PD must obtain approval from the FCF Utilization Team prior to PD implementation.

1.2 Scope

The MDCA requirements defined in this document apply to the design/development, transportation, launch/landing, and on-orbit phases of the payload cycle. Transportation requirements to and from the ISS refer to payload components that are transported in the Multi-Purpose Logistics Module (MPLM). Additionally, payload components may be transported in a Middeck Locker if limited late stowage, early retrieval, power and/or thermal conditioning is required.

Additionally, this ICD identifies generic safety interface and design requirements to which the payload must comply. The PD is required to comply with NSTS 1700.7B, NSTS 1700.7B/ISS Addendum, KHB 1700.7 and NSTS 18798 (Interpretation Letters) via the ISS safety review process.

The requirements identified in this ICD are applicable to hard-mounted payload components as well as soft-stowed items. For the purpose of this document, compatibility is defined as operating without producing an unsafe condition or one that could result in damage to CIR equipment or payload hardware.

1.3 MDCA Overview

The MDCA Flame Extinguishment Experiment (FLEX) will be conducted in the Combustion Chamber mounted to the CIR in the FCF. The MDCA is responsible only for the Principal Investigator's (PI) specific Chamber Insert Assembly (CIA), avionics package, diagnostic package and operating software.

1.3.1 Chamber Insert Assembly

The MDCA CIA provides all necessary hardware and interfaces to perform PI science on one platform. The CIA consists of two major components: an Experiment Mounting Structure (EMS) and an Internal Apparatus. Other subsystems found on the CIA include the Droplet Dispensing System, Droplet Ignition System, Droplet Deployment System, Fiber Support System and Cooling System.

1.3.1.1 Experiment Mounting Structure

The EMS provides the main structural framework for the CIA, and acts as the primary mechanical interface with the Combustion Chamber. It consists of a Locking Mechanism, Rail Brake, two endplates, support structure and removable shrouds to protect the Internal Apparatus during crew activity.

1.3.1.1.1 Locking Mechanism

The Locking Mechanism establishes precise locked axial positioning of the EMS deployment site within the Combustion Chamber after actuated engagement is made into the mating machined slot of the Combustion Chamber's shell.

1.3.1.1.2 Rail Brake

The Rail Brake is a Combustion Chamber rail clamp device that serves to assist the crew during Fuel Reservoir replacements, by securing EMS movement while in the partially withdrawn position within the Combustion Chamber.

1.3.1.2 Internal Apparatus

The Internal Apparatus provides the primary mounting platform for all experiment-specific hardware and functions such as droplet dispensing, deployment and ignition. The Internal Apparatus encompasses all motors used in the MDCA, including a cold plate cooling system, radiometers, which provide a relative measurement of flame radiation from just prior to ignition through a few seconds after extinction, and some avionics hardware. The Internal Apparatus is available for future add-on hardware for different PIs.

1.3.1.3 Droplet Dispensing System

There are two complete dispenser systems on the Internal Apparatus. The dispenser system consists of a motor housing and a replaceable Fuel Reservoir assembly. The motor housing is permanently fixed to the Internal Apparatus and contains the motor, encoder and lead screw assembly. The replaceable Fuel Reservoir assembly is situated on top of the motor housing and includes a syringe filled with the desired fuel. The syringe is covered in a tygon sleeve and is contained in an aluminum housing. The syringe is connected directly to a fuel isolation valve. The valve is a latching solenoid valve with a reed switch for status indication. The polytetraflouroethylene (PTFE) fuel line tubing is attached to the valve with a removable fitting to disconnect the fuel system from the replaceable Fuel Reservoir assembly. Fuel is dispensed by moving the lead screw via a stepper motor, which in turn pushes the plunger on the syringe.

1.3.1.4 Droplet Ignition System

The ignition system consists of two hot wire igniters opposed 180°, controlled by individual actuators. The ignition wires are 4 mm diameter loops of Kanthal A-1 wire, 30 AWG. Each loop is mounted to a ceramic structure. This entire igniter assembly is replaceable on the Internal Apparatus. The ceramic igniter sleeve has two pins that mate with two sockets on the igniter mounting interface. This interface is fixed to the igniter motors, which move the igniters into the deployment area linearly in precise steps, and quickly retract the igniters after ignition.

1.3.1.5 Droplet Deployment System

The droplet deployment system consists of two deployment needles made from 0.01 in outer diameter stainless steel tubing supported by a ceramic sleeve. Each needle is bent 90° and each needle tip is flared to aid in the droplet deployment. The needles are mounted to individual rotary servo motors with a specially designed coupling that allows replacement of the needles and maintains the precise alignment of the system. The motors rotate the needles to a pre-determined location where they are nearly tip-to-tip. Metered fuel from the dispenser is routed via the PTFE tubing to one needle forming a droplet of very precise volume. The deployment motors then actuate again, creating a slight gap between the needles. This causes the droplet to center itself between the needle tips and minimizes the contact area with the needles. Finally, the needles are rapidly accelerated apart, deploying the droplet off the needle tips. The rapid acceleration leaves the droplet in place with little or no residual motion.

1.3.1.6 Fiber Support System

The Retractable Indexing Fiber (RIF) mechanism consists of a 229 mm long, 79 μm diameter silicon carbide fiber fastened between two arms with epoxy to a tension of 3,000 psi. The use of the RIF allows the fuel droplet to be deployed onto, and thus tethered to, the fiber during experimental burn and observation. When used, the fiber is rotated 200° into the deployment area using a rotary stepping gear motor. To provide a clean portion of the fiber for successive burns, linear translation of the fiber through the deployment zone is also achievable using a second gear motor driving a pinion gear attached to a rack on the RIF assembly.

1.3.1.7 Cooling System

The cooling system uses ISS-provided cooling fluid to cool CIA components via conduction. The MDCA uses the secondary cooling loop provided by the CIR to interface to a cold plate on the surface of the Combustion Chamber insert. The system will be filled with fluid before launch and appropriate pressure and leakage tests will be conducted.

1.3.2 MDCA Avionics

The Avionics Package provides the processing and control interface hardware for controlling the MDCA and communicating with the CIR. Avionics boards are housed in a 6U compact-peripheral component interconnect (PCI) card cage and include: a single board computer; multi-axis motion controllers, which control motors and implement input and output data functions; a configurable Industry Pack carrier board for data collection; and custom multi-purpose control and power conditioning boards.

1.3.2.1 Avionics Housing

The avionics housing provides an Electromagnetic Interference (EMI) shield and a grounded enclosure for the avionics when mounted on the Optics Bench.

1.3.2.2 Power Control and Distribution

The Avionics Package receives electrical power at 28 Volts direct current (VDC) from the CIR. DC-DC converters output other necessary voltages for the Avionics Package and CIA Mechanisms.

1.3.2.3 Data and Control

The Avionics Package acquires health and status data from the CIA via dedicated Input/Output (I/O) lines in the Optics Bench. The data is downloaded to the FCF Input/Output (I/O) Processor via the FCF CIR Ethernet for downlink. MDCA commands are uplinked from the ground to the FCF I/O Processor, or issued from a Station Support Computer (SSC) to the FCF I/O Processor. The FCF I/O Processor transmits the commands to the Avionics Package via the FCF CIR Ethernet.

1.3.2.4 Interconnections

The Avionics Package blind-mates to the CIR Optics Bench. No external cables are used.

1.3.3 MDCA Diagnostics

MDCA diagnostics provide acquisition of optical and imaging information relating to the MDCA science experiments. The majority of diagnostic hardware will be CIR-provided with some additional elements or modifications provided by the MDCA. The diagnostics hardware selection and configuration is specific to the FLEX experiment.

1.3.3.1 MDCA-Provided FLEX Specific Diagnostics

1.3.3.1.1 Color Imaging

FLEX utilizes the MDCA Color Camera Package to provide color imaging of the droplet deployment area and apparatus during dispensing, deployment, ignition, and throughout the droplet burn. The camera provides the primary means of assisting in test point setup and troubleshooting. The camera includes a built-in motorized zoom lens, that can be programmed or actively controlled to cover a wide range of Field of Views (FOVs). Analog video from this package is routed to and stored in an FCF Image Processing and Storage Unit - Analog (FCF IPSU-Analog), and from there, can be made available for downlinking. Additionally, there is a means of providing white light illumination via two banks of nine white Light Emitting Diodes (LEDs), as part of the MDCA Color Camera Package, in order to view the droplet deployment area in the dark chamber.

1.3.3.1.2 Radiometers

The FLEX utilizes one Broadband Radiometer to measure radiative emissions from 1.0 - 5.0 μm at a sampling rate of 10 Hz. A second Narrowband Radiometer measures radiative emissions in the H_2O band centered at 1.87 μm at a sampling rate of 10 Hz.

1.3.4 Software

The MDCA software provides total control of the MDCA hardware and PI-specific diagnostic equipment. The software provides ground control of all aspects for experiment operation and communication between the MDCA processor, CIR processors and ISS processors. The MDCA software interfaces with CIR controls to utilize CIR diagnostics in obtaining data for the experiments. MDCA software can be decomposed into three main functions: Main Computer software, Crew Interface software, and FCF I/O Processor interface software.

1.3.4.1 Main Computer Software

The MDCA single board computer resides inside the PI-specific Avionics Package within the CIR. The Avionics Package receives commands from the SSC, or another ISS data system, via the FCF I/O Processor. The Main Computer communicates with the CIR Fuel/Oxidizer Management Assembly (FOMA) Control Unit and FCF IPSUs via the FCF I/O Processor. Depending on the command, the Main Computer sends data to the FCF I/O Processor or it executes a series of low-level commands to cause the hardware to perform a series of operations. The software that interfaces with the Main Computer software is divided into several areas: Avionics Package, CIA, and Diagnostics.

1.3.4.1.1 Avionics Package

The Avionics Package provides the processing and control interface hardware for controlling the CIA and the diagnostic equipment.

1.3.4.1.2 Chamber Insert Assembly

The MDCA software controls the CIA mechanical devices used to dispense, deploy and ignite droplets. The MDCA Color Camera is located on the CIA and is completely controlled by MDCA software.

1.3.4.1.3 Diagnostics

Most diagnostic capabilities are provided by the CIR. The MDCA interfaces with the diagnostic packages via the FCF I/O Processor. (Refer to FCF-ICD-0076 for more information.)

Consistent with the capabilities of the MDCA software will be the ability to coordinate diagnostic events, within the CIR, with events such as the Automated Sequence (the sequence during which the droplet is dispensed, deployed, and ignited) and off-nominal events. This traffic between MDCA and the diagnostic packages passes through the FCF I/O Processor.

1.3.4.2 Crew Interface Software

The Crew Interface software resides on the SSC, an external computer provided by the ISS. The SSC will run software written by the MDCA Software Team that allows the ISS crew to setup, monitor, and operate the experiments. The SSC is connected to ISS data systems and the CIR via Ethernet. The SSC will interface with the MDCA via the FCF I/O Processor. Commands issued by the crew for the experiments originate at the SSC. The Crew Interface software will package the commands for transmission to the FCF I/O Processor and ultimately the MDCA Main Computer. The Crew Interface software will receive and display engineering and science data from the MDCA Main Computer.

1.3.4.3 FCF I/O Processor Interface Software

The FCF I/O Processor is the data interface between the MDCA Main Computer and the CIR systems. Engineering and science data is transmitted via the FCF I/O Processor to the SSC and ISS data systems for transmission to ground systems. Command data from ISS data systems and the SSC are transmitted to the MDCA Main Computer via the FCF I/O Processor. The MDCA Main Computer's communication with the CIR diagnostic packages, FCF IPSUs, and the FCU is transmitted through the FCF I/O Processor.

1.4 Combustion Integrated Rack Payload Accommodations

Should MDCA utilize interfaces other than those stated in this ICD or use interfaces in a manner not described in this ICD, they will be using non-standard interfaces. This classification is based solely upon the evaluation of each interface between the CIR and MDCA. This classification does not imply that the MDCA cannot be manifested in CIR; however, it does provide the MDCA Development Team a top-level indication regarding the payload complexity. The MDCA Development Team, regardless of the payload design complexity, shall support all generic integration templates as shown in FCF-IA-MV-MDCA.

The interfaces that are dependent on ISS resources, (i.e., cooling water, vacuum exhaust, Gaseous Nitrogen (GN_2)) are limited in quantity and are negotiated and documented in the MDCA IA Data Set.

1.5 Precedence

In the event of an inconsistency among the payload integration documentation contained within section 2.1 of this document, resolution shall be achieved by observing the following order of precedence:

A. ISS Safety Documents
B. Payload Integration Agreement for Fluids and Combustion Facility (SSP 57117)
C. Fluids and Combustion Facility (FCF) Combustion Integrated Rack (CIR) Hardware Interface Control Document (SSP 57217)
D. Multi-User Droplet Combustion Apparatus Integration Agreement Main Volume (FCF-IA-MV-MDCA)
E. Multi-User Droplet Combustion Apparatus Interface Control Document (FCF-ICD-CIR-MDCA)

1.6 Effectivity

Unless otherwise specified, the interfaces defined and controlled herein are applicable to the operational configuration of the CIR.

1.7 Change Policy

This document is under the CM of the MRDOC Control Board per MRD-PLN-0002; however, any changes or revisions to the baseline version must be approved by the ESD Control Board Chair.

2.0 DOCUMENTATION

2.1 Applicable Documents

The following documents shall form a part of this document to the extent specified herein. Unless the exact issue and date are identified, the "Current Issue" applies. In addition, the PD shall adhere to requirements as found in Payload Control Board approved Preliminary Interface Revision Notices (PIRNs). PIRNs are routed to the PD per MRD-PRC-0137.

2.1.1 Government Documents

CIR-DOC-1072	Detonation Control Plan for CIR Payloads
CIR-SCD-0300	Combustion Chamber Window Material
FCF-DOC-0070	Common IPSU Software Design
FCF-DOC-0118	Engineering Design and Assembly Guidelines
FCF-DOC-1760	FCF Java Application Programmer's Interface Description
FCF-GPVP-CIR	Combustion Integrated Rack Generic Payload Verification Plan
FCF-IA-MV-MDCA	Multi-User Droplet Combustion Apparatus Integration Agreement Main Volume
FCF-ICD-0076	Software Interface Control Document - Fluids and Combustion Facility
FCF-IDD-CIR	Combustion Integrated Rack Payload Interface Definition Document
FCF-LST-0874	FCF Software Signal List
FCF-PLN-0029	Fastener Control Plan
FCF-PLN-0033	Integrated Logistics Support Plan
FCF-PLN-0788	FCF Training Plan
FCF-PLN-0875	FCF Utilization Process
FCF-PVP-CIR-MDCA	Multi-User Droplet Combustion Apparatus Payload Verification Plan
FCF-REQ-0767	Central Data System Requirements Document
FED-STD-101	Test Procedures for Packaging Materials
KHB 1700.7	Space Transportation System Payload Ground Safety Handbook

MIL-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys April 14, 1981
MIL-C-81659	Connectors, Electrical Rectangular, Crimp Contact
MIL-C-81706	Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys
MIL-C-83513	Micro miniature D Connectors
MIL-F-85720	Fitting, Tube, Fluid Systems, Separable, High Pressure, Dynamic Beam Seal
MIL-STD-2154	Process for Ultrasonic Inspection of Wrought Metals
MRD-MAN-0133 **<TBD 02-01>**	FCF Software User's Manual
MRD-PRC-0137	FCF Exception Process
MS33514	Male Flareless Fitting Seal
MS33515	Male Flareless Fitting
MS33649	Fluid Connection – Internal Straight Thread Boss
MS33656	Standard Dimensions for Flared Tube Connection and Gasket Seal Fitting End
MS33657	Bulkhead Tube
MS33677	Fitting End, Taper Pipe Thread, Standard Dimensions for FSC 4730
MSFC-DOC-2800	Telescience Resource Kit Application Programming Interface Reference Manual
MSFC-HDBK-527/JSC 09694	Materials Selection List for Space Hardware System
MSFC-SPEC-250	Protective Finishes for Space Vehicle Structures and Associated Flight Equipment
MSFC-STD-3029	Design Criteria for Stress Corrosion Cracking
NASA-STD-5003	Fracture Control Requirements for Payloads (previously NHB 8071.1) Using the National Space Transportation System (NSTS)
NASA-STD-6001	Flammability, Odor, and Offgassing and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion
NASA-STD-7001	Payload Vibroacoustic Test Criteria

NASA TM 102179	NASA Technical Memo 102179
NSTS 13830	Implementation Procedure for NSTS Payloads System Safety Requirements
NSTS 1700.7B	Safety Policy and Requirements for Payloads Using the Space Transportation System
NSTS 1700.7B/ISS Addendum	Safety Policy and Requirements for Payloads Using the International Space Station
NSTS 18798	Interpretation of NSTS Payload Safety Requirements
NSTS 20793	Manned Space Vehicle Battery Safety Handbook
NSTS 21000-IDD-MDK	Middeck Interface Definition Document
NSTS 22648	Flammability Configuration Analysis for Spacecraft Application
SSP 30233	Space Station Requirements for Materials and Processes
SSP 30237E	Electromagnetic Emission and Susceptibility Requirements September 15, 1999
SSP 30240	Space Station Grounding Requirements
SSP 30242	Space Station Cable/Wire Design and Control Requirements for Electromagnetic Compatibility
SSP 30245	Space Station Electrical Bonding Requirements
SSP 30426	External Contamination Control Requirements
SSP 30573	Space Station Program Fluid Procurement and Use Control Specification
SSP 41000	System Specification for the International Space Station
SSP 50005	International Space Station Flight Crew Integration Standard (NASA-STD-3000/T)
SSP 50304	POIC Capabilities Document
SSP 50305 v. 1 and 2	POIC to Generic User Interface Definition Document
SSP 50313	Payload Display and Graphics Commonality Standards
SSP 50467	ISS Stowage Accommodations Handbook: Pressurized Volume
SSP 50481	ISS Management Plan for Waste Collection and Disposal
SSP 52000	Payload Integration Agreement Blank Book For Pressurized Payloads

SSP 52005	International Space Station Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures
SSP 54001	Space Station Program Support Requirements System Network Program Requirements Document
SSP 57000	Pressurized Payloads Interface Requirements Document
SSP 57117	Fluids and Combustion Facility Integration Agreement
SSP 57217	Fluids and Combustion Facility (FCF) Combustion Integrated Rack (CIR) Hardware Interface Control Document
TADS-USER-003	**<TBD 02-02>**
TSC-DOC-004	GRC Telescience Support Center Implementation Plan
TREK-USER-003	TreK Telemetry Processing User Guide

2.1.2 Non-Government Documents

ANSI Z-136.1-1993	American National Standard for Safe Use of Lasers
ASME/ANSI B18.3.1M	Hexagon Socket Button Head Cap Screws
ASME/ANSI B46.1	Surface Texture, Surface Roughness, Waviness and Lay
ASTM E1417	Standard Practice for Liquid Penetrant Examination
EIA RS-170	Electrical Performance Standards – Monochrome Television Studio Facilities, November 1957
EIA RS-170A	Color Television Studio Picture Line Amplifier Output Drawing, November 8, 1977
IEEE 802.3	Institute of Electrical and Electronic Engineers 802.3 (Ethernet) Standard, Carrier Sense Multiple Access with Collision Detection (CSMS/CD) Access Method and Physical Layer Specification Type 10BASE-T
ISO 11898	Road Vehicles-Controller Area Network
NC-40	Noise Criteria Curves created as design guidelines for HVAC system noise in unoccupied spaces established by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
NC-45	Noise Criteria Curves created as design guidelines for HVAC system noise in unoccupied spaces established by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

2.2 Reference Documents

The following documents are specified herein for reference only and are not a part of this document. Unless the exact issue and date are identified, the "Current Issue" applies.

ANSI S1.4	Specification for Sound Level Meters Amendment S1.4A-1985 ASA 47 R
ANSI S1.11	Specification for Octave–Band and Fractional–Octave–Band Analog and Digital Filters; ASA 65-1986 R (1993)
ANSI S12.12-1992	Engineering Method for the Determination of Sound Power Levels of Noise Sources using Sound Intensity ASA 104
ANSI S12.23-1989	Method for the Designation of Sound Power Emitted by Machinery and Equipment
ANSI S12.31-1990	Precision Methods for Determination of Sound Power Levels of Broad–band Noise Sources in Reverberation Rooms
ANSI S12.32-1990	Precision Methods for the Determination of Sound Power Levels of Discrete Frequency and Narrow–band Noise Sources in Reverberation Rooms
ANSI S12.33-1990	Engineering Methods for the Determination of Sound Power Levels of Noise Sources in a Special Reverberation Test Room
ANSI S12.34-1988	Engineering Methods for the Determination Sound Power Levels of Noise Sources for Essentially Free–field Conditions over a Reflecting Plane
ANSI-S12.35-1990	Precision Methods for the Determination of Sound Power Levels of Noise Sources in Anechoic and Hemi–anechoic Rooms
ANSI-S12.36-1990	Survey Methods for the Determination of Sound Power Levels of Noise Sources
CIR-SPC-1323	Critical Item Product Specification: Optics Bench Assembly
FCF-SPC-0001	System Specification Fluids and Combustion Facility
FCF-SPC-0002	Prime Item Development Specification: Combustion Integrated Rack Fluids and Combustion Facility
ISO 9614-2	Acoustics - Determination of Sound Power Levels of Noise Sources using Sound Intensity - Part 2: Measuring by Scanning
MIL-C-26074	Coatings, Electroless Nickel Requirements

3.0 PHYSICAL AND MECHANICAL INTERFACES

3.1 Optics Bench

3.1.1 Universal Mounting Locations

Payload components that do not attach to the standard FCF-provided Diagnostic Control Module (FCF DCM) shall be mounted to the rear of the Optics Bench at one of eight Universal Mounting Locations (UMLs) utilizing either the UML mounting holes or the threaded mounting holes. Each UML position provides mechanical, air-cooling, and electrical interfaces. The electrical interface provides 28 Voltage Direct Current (VDC) power, analog video, location address, Controller Area Network (CAN) Bus, and Sync Bus interfaces. The general layout of the UML is shown in FIGURE 1. The locations of the UMLs are shown in FIGURE 2.

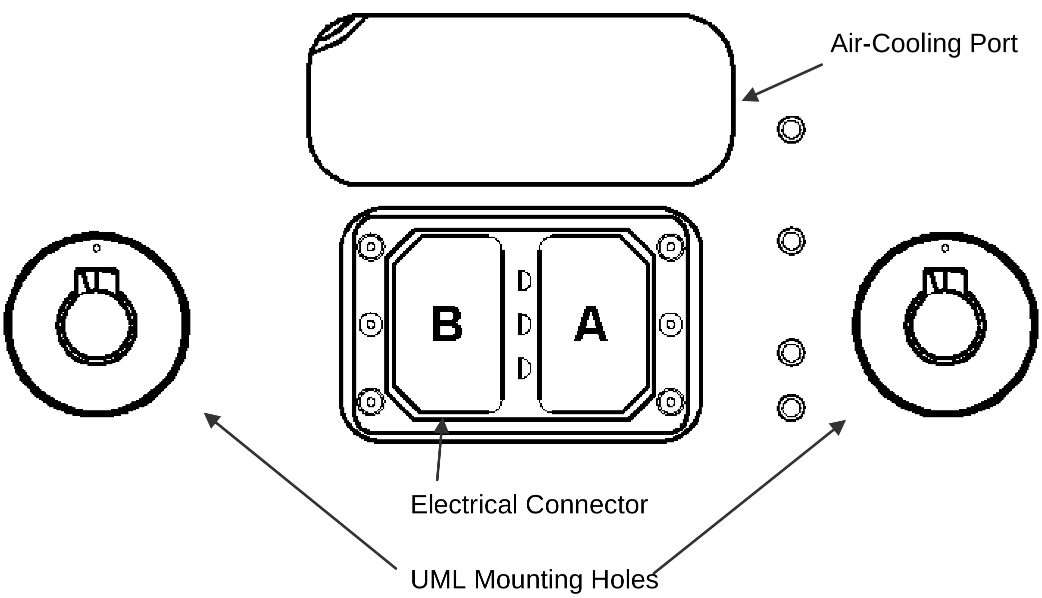
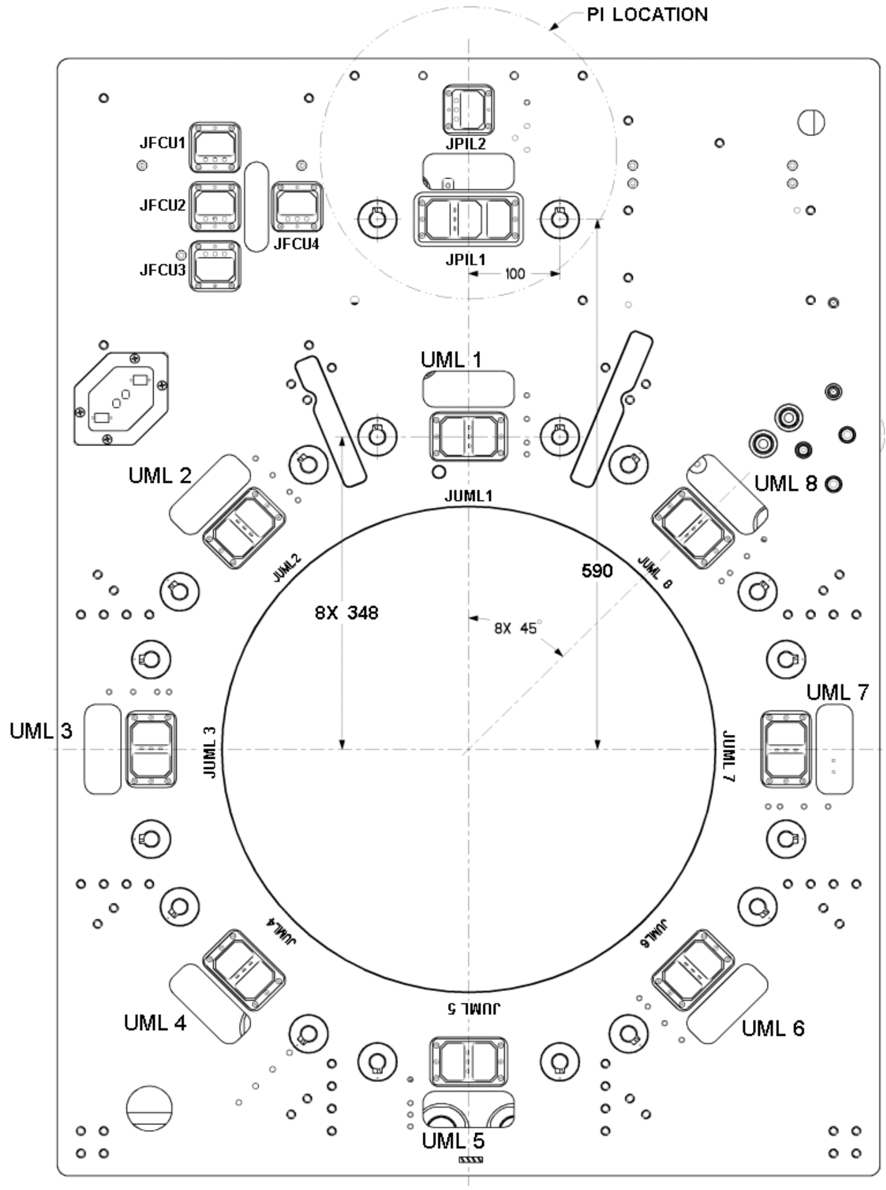


FIGURE 1 UML INTERFACES

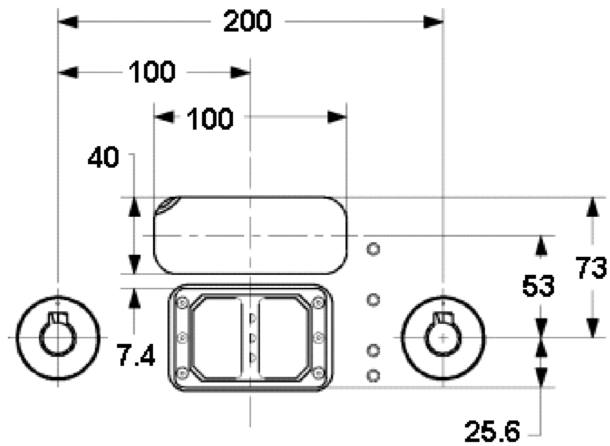


Note: All dimensions in millimeters

FIGURE 2 UML LOCATIONS ON REAR OF THE OPTICS BENCH

3.1.1.1 Universal Mounting Location Mounting Interface

Payload components can mount to the UML utilizing two mounting holes. The location of these holes with respect to the electrical connector and air-cooling port is shown in FIGURE 3. Payload components utilizing the mounting holes shall comply with the FCF UML Latch Handle provisions identified in section 3.1.1.5 of this document.



Note: All dimensions in millimeters

FIGURE 3 UML MECHANICAL INTERFACES

3.1.1.2 Universal Mounting Location Threaded Mounting Holes

Payload components that utilize the UML threaded mounting holes shall utilize ¼ - 28 UNF-3A threaded fasteners. The location of the UML threaded mounting holes is shown in FIGURE 4. The threaded engagement depth for the UML threaded mounting holes shall not exceed 9.3 mm (0.37 in).

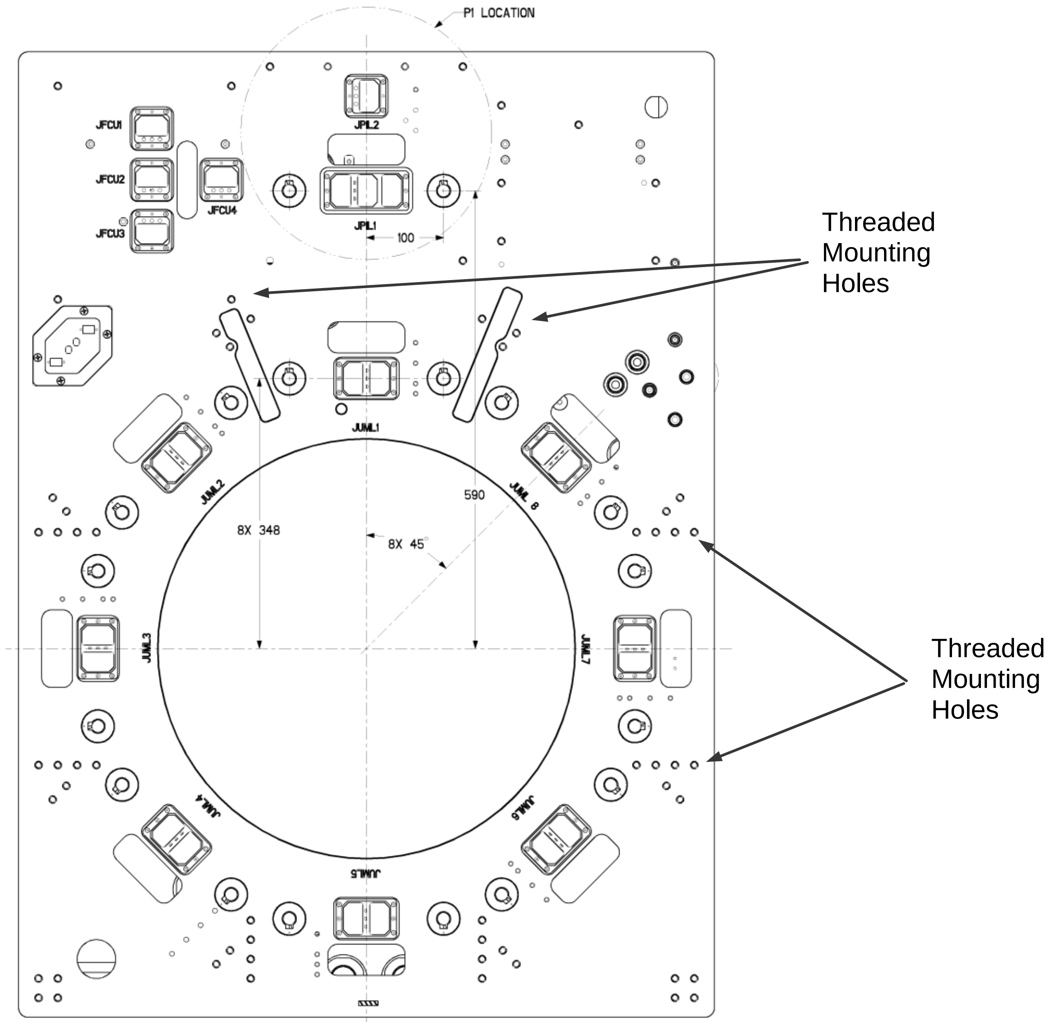


FIGURE 4 UML THREADED MOUNTING HOLE INTERFACES

3.1.1.3 Universal Mounting Location Electrical Connector

Payload components shall incorporate the receptacle half of the ARINC style electrical connector. The manufacturer's part numbers for both halves of the electrical connectors are provided in TABLE 1 .

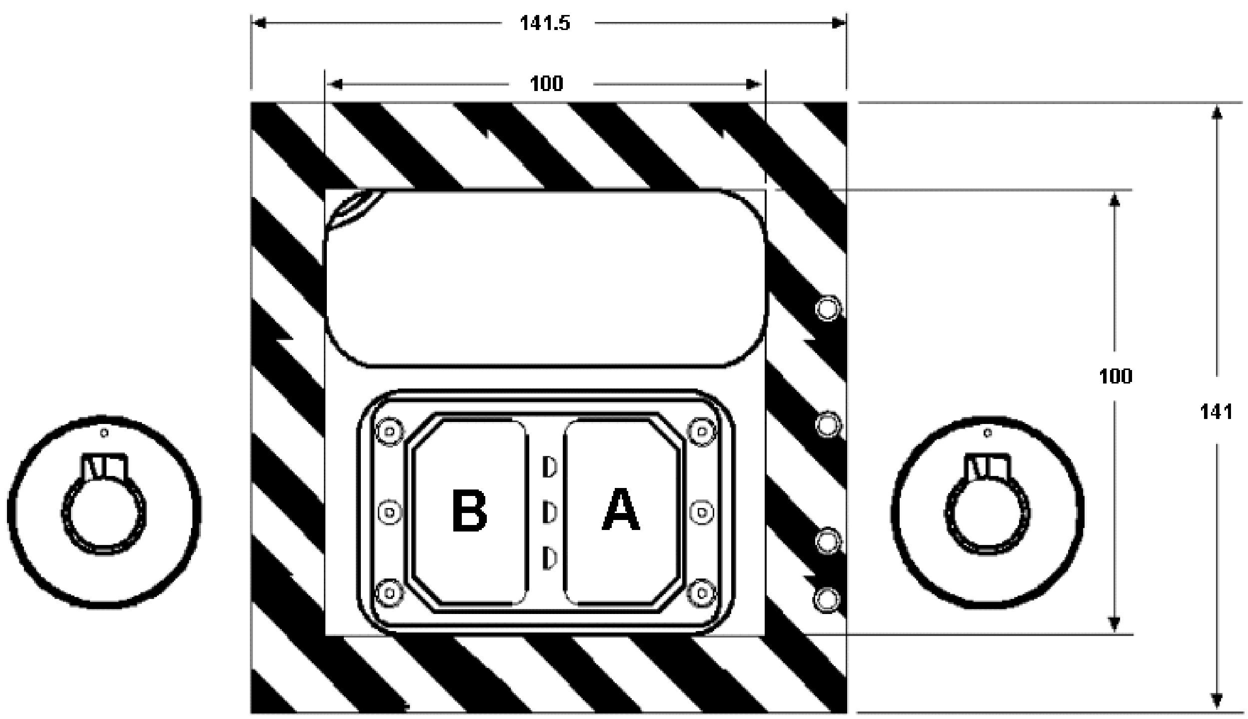
TABLE 1 UML ELECTRICAL CONNECTOR AND MATING PART NUMBERS

Connector	Manufacturer Radiall	Description (1)
CIR UML 1-8	DSXN-2R-S106P-S26S-6301	2 Bay receptacle (106) #22 AWG pins, (26) #16 AWG sockets
Payload	DSXN-2P-S106S-S26P-6001	2 Bay plug (106) #22 AWG sockets, (26) #16 AWG pins

Note: (1) All non-environmental, crimp contacts, normal keying, electroless nickel plating, physical dimensions per MIL-C-81659

3.1.1.4 Universal Mounting Location Air-Cooling Interface

Payload components that require air-cooling from the UML shall be compatible with the air-cooling port geometry specified in FIGURE 3 and the sealing area shown in FIGURE 5.



Note: All dimensions in millimeters

FIGURE 5 UML PAYLOAD SEAL LOCATION

3.1.1.5 FCF Universal Mounting Location Latch Handle Provisions

Payload components that attach to the UML mounting holes shall utilize the FCF-provided FCF UML Latch Handle as shown in FIGURE 6. Payload components shall be equipped with the provisions specified in FIGURE 7 to allow mounting with the FCF UML Latch Handle.

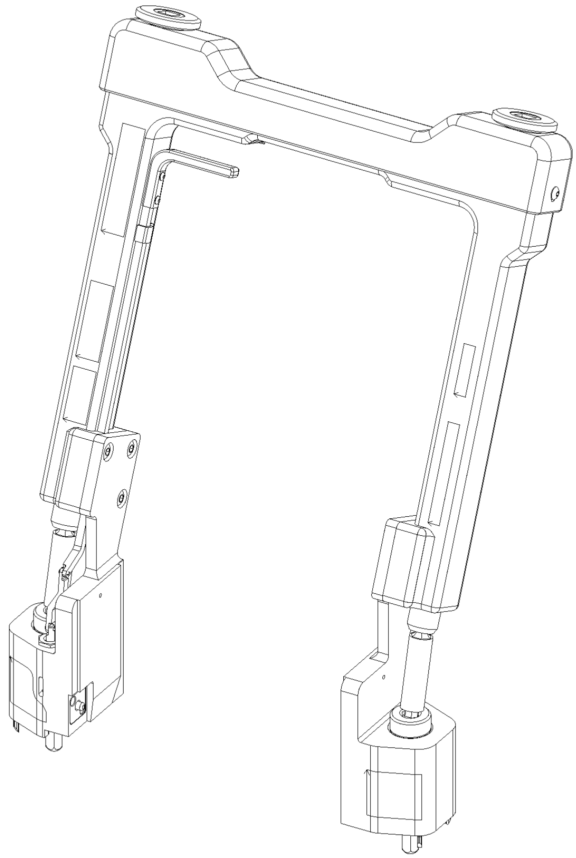
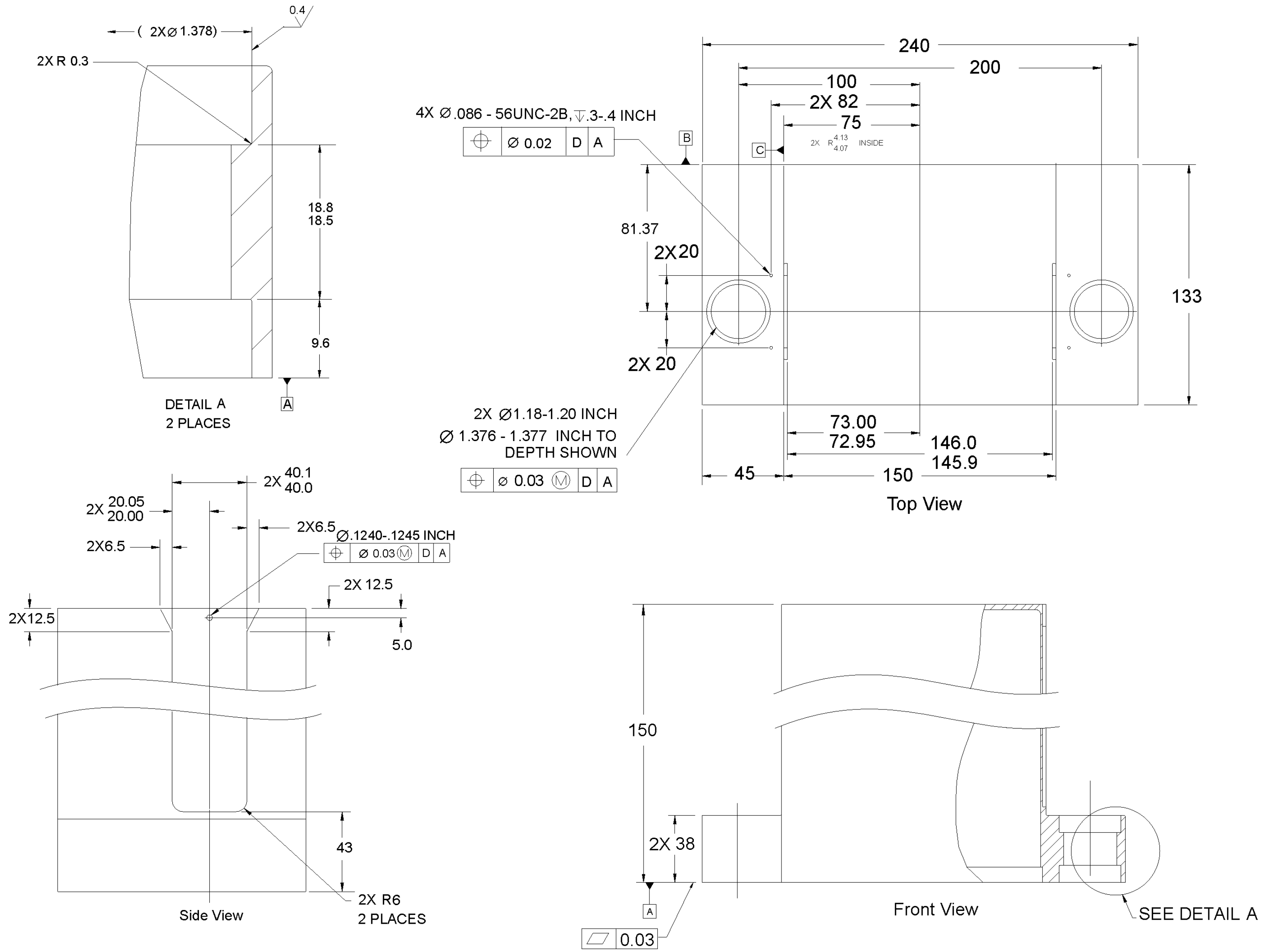


FIGURE 6 FCF UML LATCH HANDLE



Note: All dimensions in millimeters unless otherwise noted.

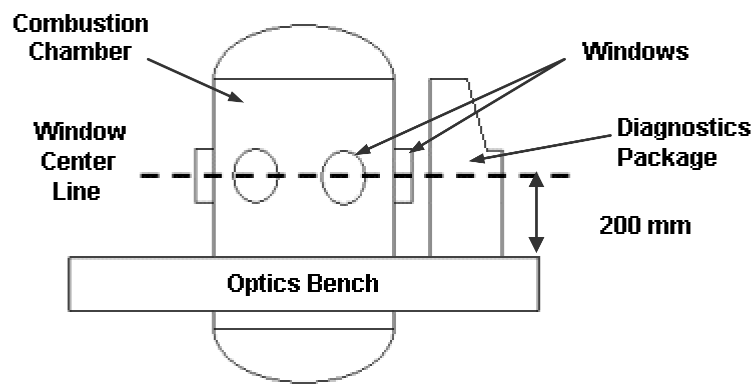
FIGURE 7 PAYLOAD COMPONENT PROVISIONS FOR FCF UML LATCH HANDLE

3.1.1.6 Universal Mounting Location Mounted Hardware Envelope

3.1.1.6.1 Payload-Provided Components

Payload components that mount to the UML positions shall not exceed the maximum envelope dimensions shown in FIGURE 8 and FIGURE 9.

If the FCF UML Latch Handle is used to mount the payload components, then refer to the requirements of section 3.1.1.5 of this document.



Note: All dimensions in millimeters

FIGURE 8 HARDWARE MOUNTING CONCEPT

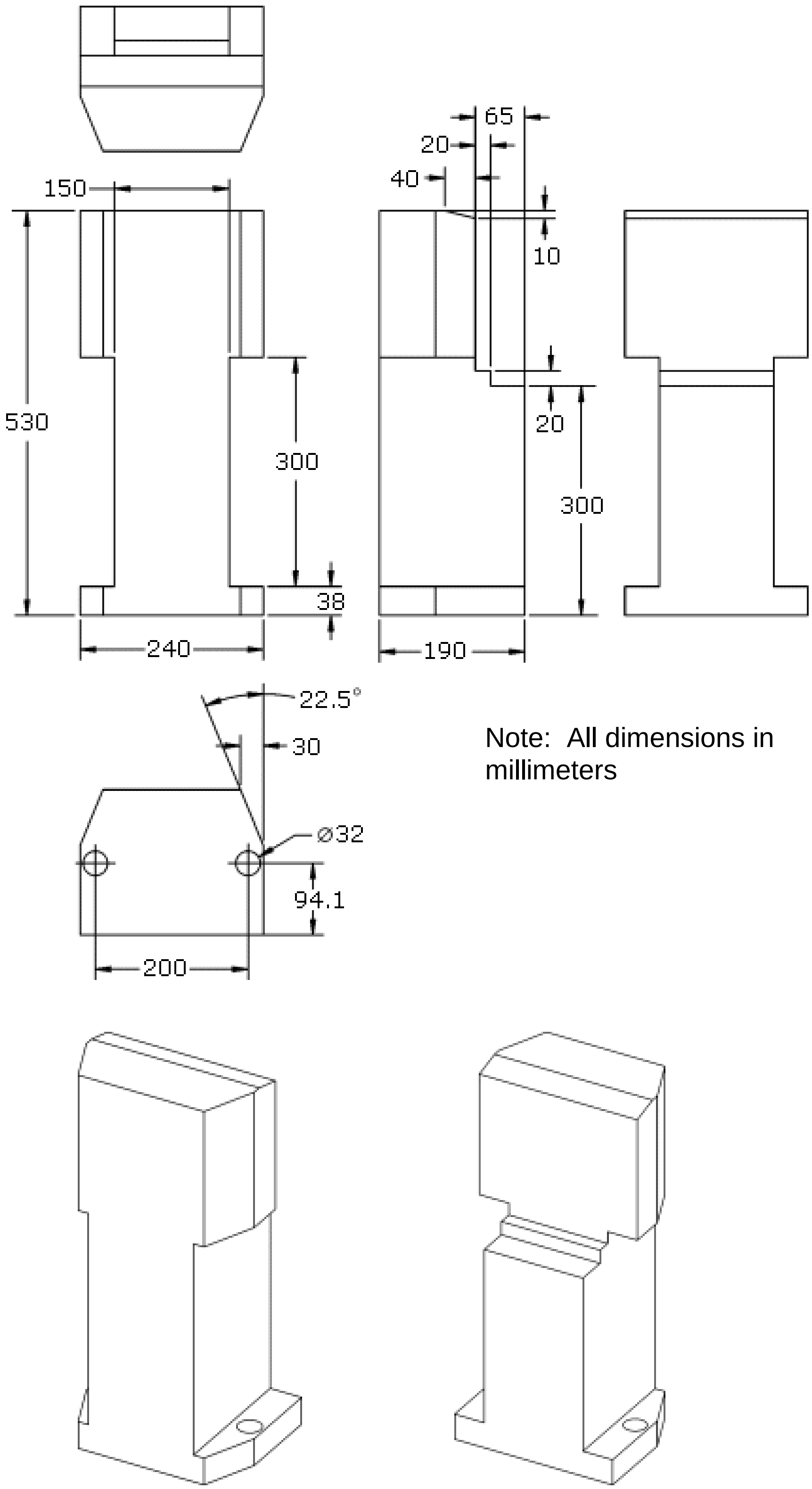


FIGURE 9 HARDWARE ENVELOPE REQUIREMENTS

3.1.1.6.2 CIR-Provided Components

The layout of CIR-provided components that mount to the UML positions shall comply with TABLE 2 and TABLE 3 .

TABLE 2 UML CONFIGURATIONS

CONFIGURATION	UML POSITIONS							
	1	2	3	4	5	6	7	8
CIR HFR/HR Imaging Package								
50 mm Same [(1)]	N	N	Y	Y	N	N	Y	Y
50 mm Same Flipped [(1) (3)]	N	N	Y	Y	N	Y	N	N
50 mm Opposite [(2)]	N	Y	Y	N	N	Y	Y	N
50 mm Opposite Flipped [(2) (3)]	N	N	Y	Y	N	Y	Y	N
CIR HiBMS Imaging Package								
30 mm, 50 mm, 90 mm Same [(1)]	N	Y	Y	Y	Y	Y	Y	Y
30 mm, 50 mm, 90 mm Same Flipped [(1) (3)]	N	Y	Y	Y	Y	Y	N	N
30 mm, 50 mm, 90 mm Opposite [(2)]	N	Y	Y	Y	Y	Y	Y	N
30 mm, 50 mm, 90 mm Opposite Flipped [(2) (3)]	N	N	Y	Y	Y	Y	Y	N
CIR LLL-UV Imaging Package								
50mm, 80mm	N	Y	Y	Y	Y	Y	Y	Y
CIR LLL-IR Imaging Package								
50mm	N	Y	Y	Y	Y	Y	Y	Y
CIR ICM								
Base Configuration	Y	Y	Y	Y	Y	Y	Y	Y
FCF IPSU/IPSU-Analog and CIR IPSU Adapter	N	N	Y	N	Y	N	Y	N
FCF IPSU/IPSU-Analog and CIR IPSU Corner Adapter	N	Y	N	N	N	N	N	N
FCF IPSU/IPSU-Analog (Stacked) and CIR IPSU Adapter	N	N	Y	N	Y	N	Y	N
FCF IPSU/IPSU-Analog (Stacked) and CIR IPSU Corner Adapter	N	N	N	N	N	N	N	N

Notes:
(1) Same - the IAM is on the same side as the Air-cooling duct.
(2) Opposite – the IAM is on the opposite side as the Air-cooling duct.
(3) Flipped – the focus prism is rotated 180°.

TABLE 3 ALLOWABLE CONFIGURABLE HARDWARE POSITIONS

	Right Package – Facing Chamber						
Left Package – Facing Chamber	CIR HiBMS Imaging Package, CIR HFR/HR Imaging Package Same	CIR HiBMS Imaging Package, CIR HFR/HR Imaging Package Opposite	FCF IPSU and CIR IPSU Adapter	FCF IPSU (Stacked) and CIR IPSU Adapter	CIR IPSU Corner Adapter	CIR LLL-UV Imaging Package, CIR LLL-IR Imaging Package	CIR ICM
CIR HiBMS Imaging Package, CIR HFR/HR Imaging Package Same	Y	Y	Y?	Y?	Y	Y	Y
CIR HiBMS Imaging Package, CIR HFR/HR Imaging Package Opposite	N	Y	N	N	Y	Y	Y
FCF IPSU and CIR IPSU Adapter	N	Y	Y	Y	Y	Y	Y
FCF IPSU (Stacked) and CIR IPSU Adapter	N	Y	Y	Y	Y	Y	Y
CIR IPSU Corner Adapter	Y	Y	Y	Y	Y	Y	Y
CIR LLL-UV Imaging Package, CIR LLL-IR Imaging Package	Y	Y	Y	Y	Y	Y	Y
CIR ICM	Y	Y	Y	Y	Y	Y	Y

Y = Yes, acceptable pairing
Y? = Yes likely, must be tested
N = No, unacceptable pairing

3.1.2 Principal Investigator Location

The payload-provided Principal Investigator (PI) Avionics Package mounts to the rear of the Optics Bench at the Principal Investigator Location (PIL). The location of the PIL on the Optics Bench is shown at the top center of FIGURE 4. The PIL provides mechanical, air-cooling, and electrical interfaces as shown in FIGURE 10. The PI Avionics Package shall mount to the PIL utilizing either the PIL mounting holes or the threaded mounting holes.

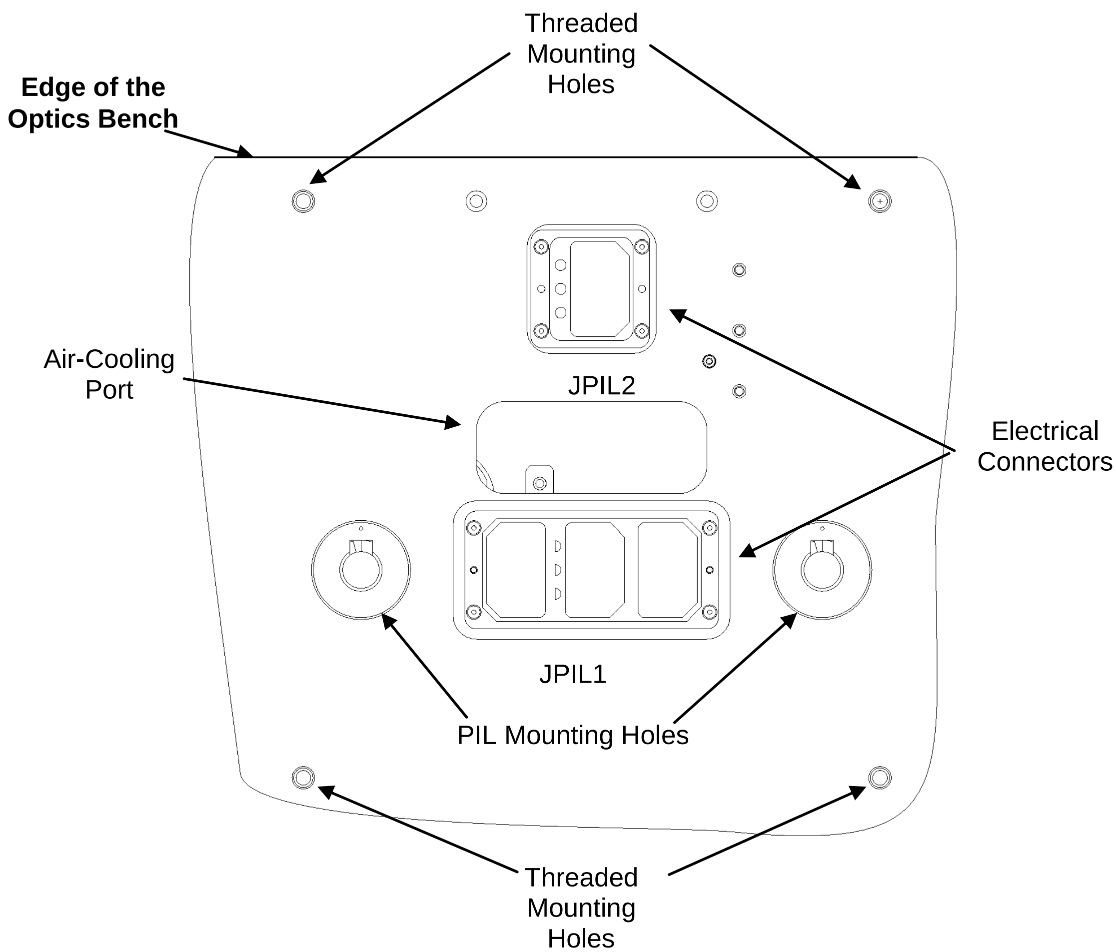


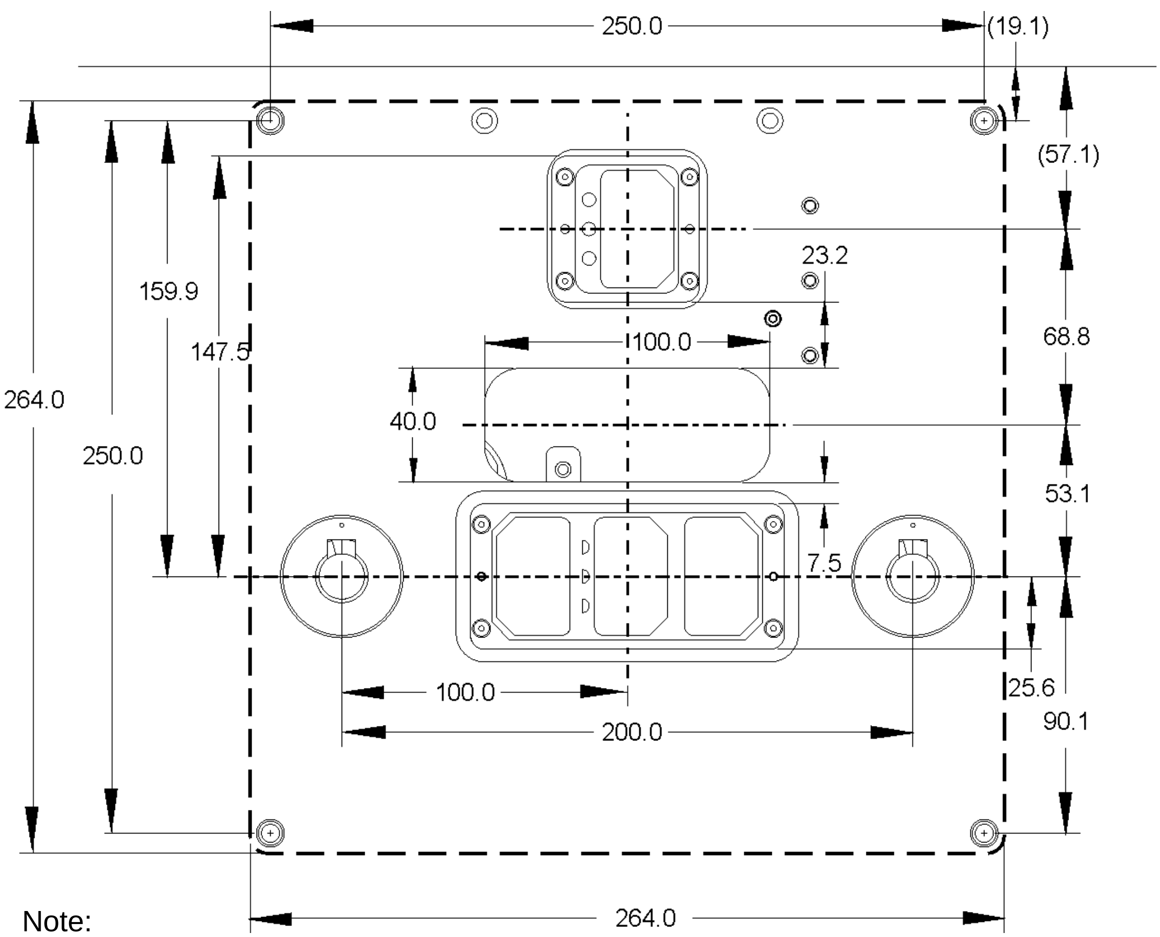
FIGURE 10 PIL INTERFACES

3.1.2.1 Principal Investigator Location Mounting Holes

The PI Avionics Package can mount to the PIL utilizing the PIL mounting holes shown in FIGURE 11. If the PIL mounting holes are to be utilized, then the PI Avionics Package shall comply with the FCF UML Latch Handle provisions identified in section 3.1.1.5 of this document.

3.1.2.2 Principal Investigator Location Threaded Mounting Holes

A PI Avionics Package that utilizes the PIL threaded mounting holes shall utilize the ¼ -20 UNC-2B threaded mounting holes as shown in FIGURE 11. The threaded depth of the top left, top right, bottom right, and bottom left mounting holes shall not exceed 9.3 mm (0.37 in). The threaded depth of the two remaining threaded mounting holes shown on the top center of FIGURE 11 shall not exceed 4.7 mm (0.19 in).



Note:

1. All dimensions in millimeters.
2. The 264.0 X 264.0 dashed outline details the relationship of the PI Avionics Package shown in FIGURE 13, to the PIL.

FIGURE 11 PIL MECHANICAL INTERFACE DETAILS

3.1.2.3 Principal Investigator Location Electrical Connectors

The PIL provides 28 VDC power to the PI Avionics Package, an Ethernet interface with the FCF I/O Processor and configurable power and data connections between the PI Avionics Package, the Combustion Chamber, and the Fuel/Oxidizer Management Assembly (FOMA) Control Unit. 120 VDC power may be routed to the PIL from the 120 VDC connector (JPHV1) as defined in section 3.5 of this document.

The PIL contains two ARINC connectors designated as JPIL1 and JPIL2. The “J” denotes that the connector is the receptacle half of the connection. The PI Avionics Package shall incorporate the plug half, PPIL1 and PPIL2, of the ARINC electrical connectors. The “P” denotes that the PI Avionics Package shall provide the plug half of the connector. The manufacturer’s part numbers for both halves of the electrical connectors are provided in TABLE 4 .

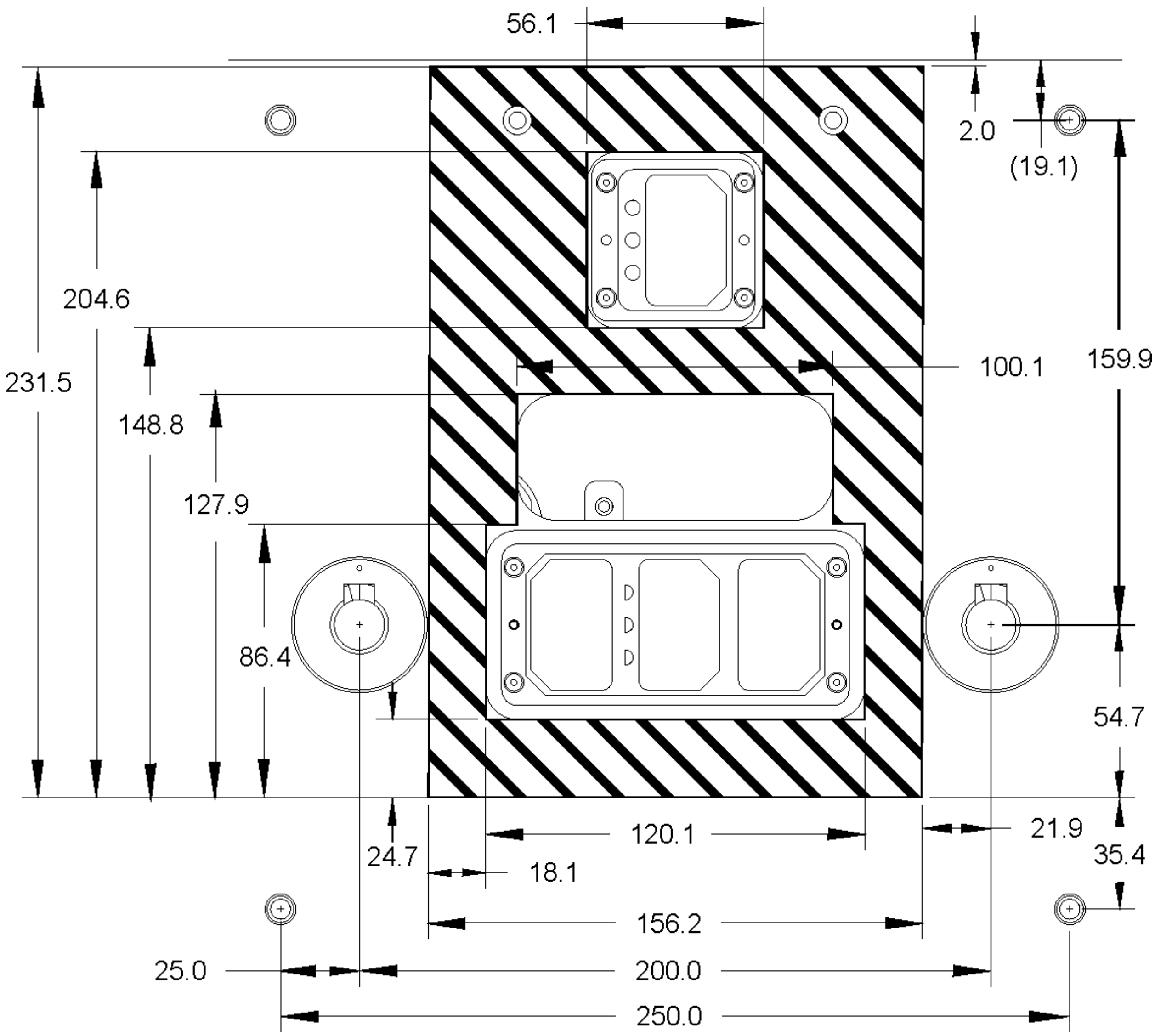
TABLE 4 PIL ELECTRICAL CONNECTORS AND MATING PART NUMBERS

Connector	Manufacturer RADIALL	Description (1)
JPIL1 (CIR)	DSXN3R-S106P-S106P-S57S-6301	3 Bay receptacle (106) #22 AWG pins, (106) #22 AWG pins, (57) #20 AWG sockets, floating eyelets
JPIL2 (CIR)	DSXN1R-S26S-6301	1 Bay receptacle (26) #16 AWG sockets, floating eyelets
PPIL1 (PI Avionics Package)	DSXN3P-S106S-S106S-S57P-6001	3 Bay plug (106) #22 AWG sockets, (106) #22 AWG sockets, (57) #20 AWG pins
PPIL2 (PI Avionics Package)	DSXN1P-S26P-6001	1 Bay plug (26) #16 AWG pins

Note: (1) All non-environmental, crimp contacts, normal keying, electroless nickel plating, physical dimensions to MIL-C-81659

3.1.2.4 Principal Investigator Location Air-Cooling Interface

Payload components shall be compatible with the PIL air-cooling port geometry specified in FIGURE 11 and the sealing area shown in FIGURE 12.

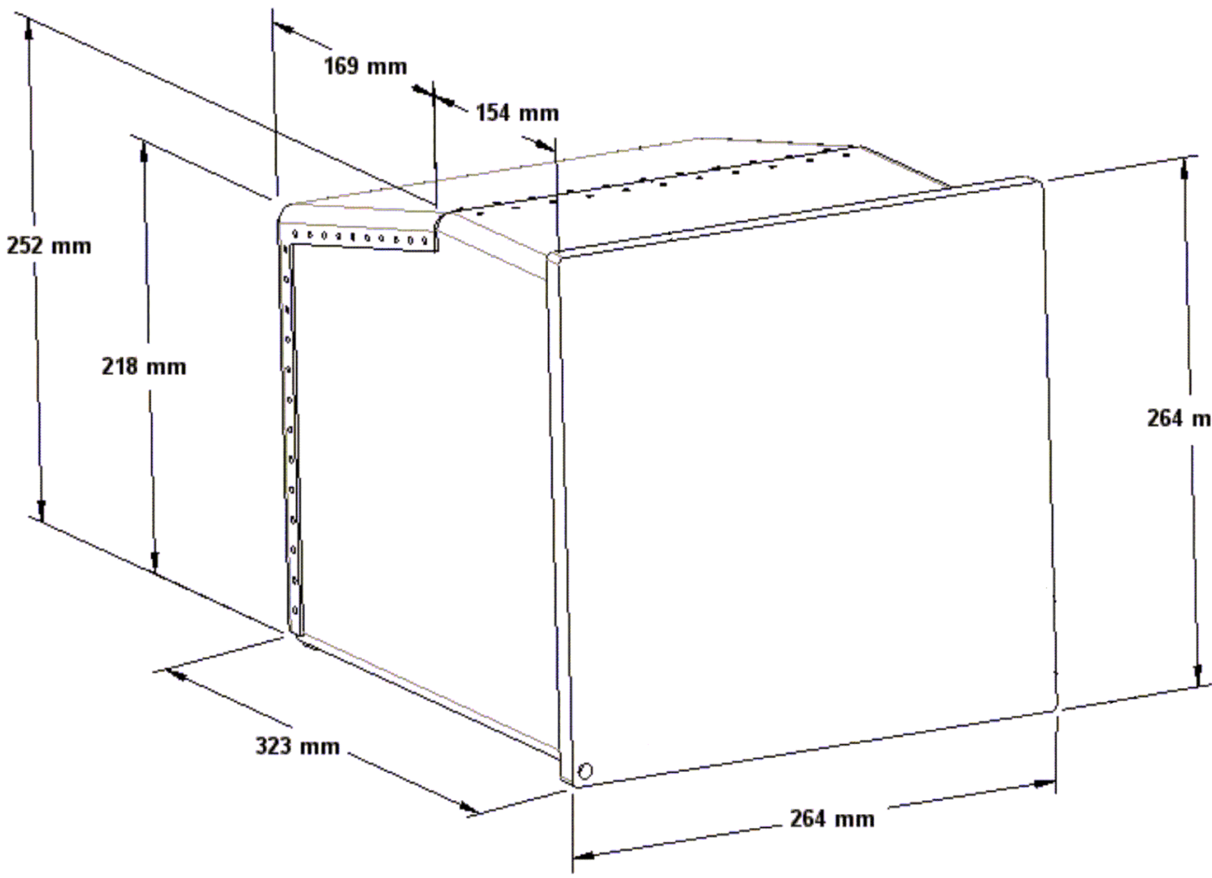


Note: All dimensions in millimeters

FIGURE 12 PIL PAYLOAD SEAL LOCATION

3.1.2.5 Principal Investigator Location Avionics Package Envelope

Payload components that mount to the PIL shall not exceed the maximum envelope dimensions for the PI Avionics Package as shown in FIGURE 13. If the FCF UML Latch Handle is to be utilized for mounting, the PI Avionics Package shall comply with the requirements of section 3.1.1.5 of this document.



Note:

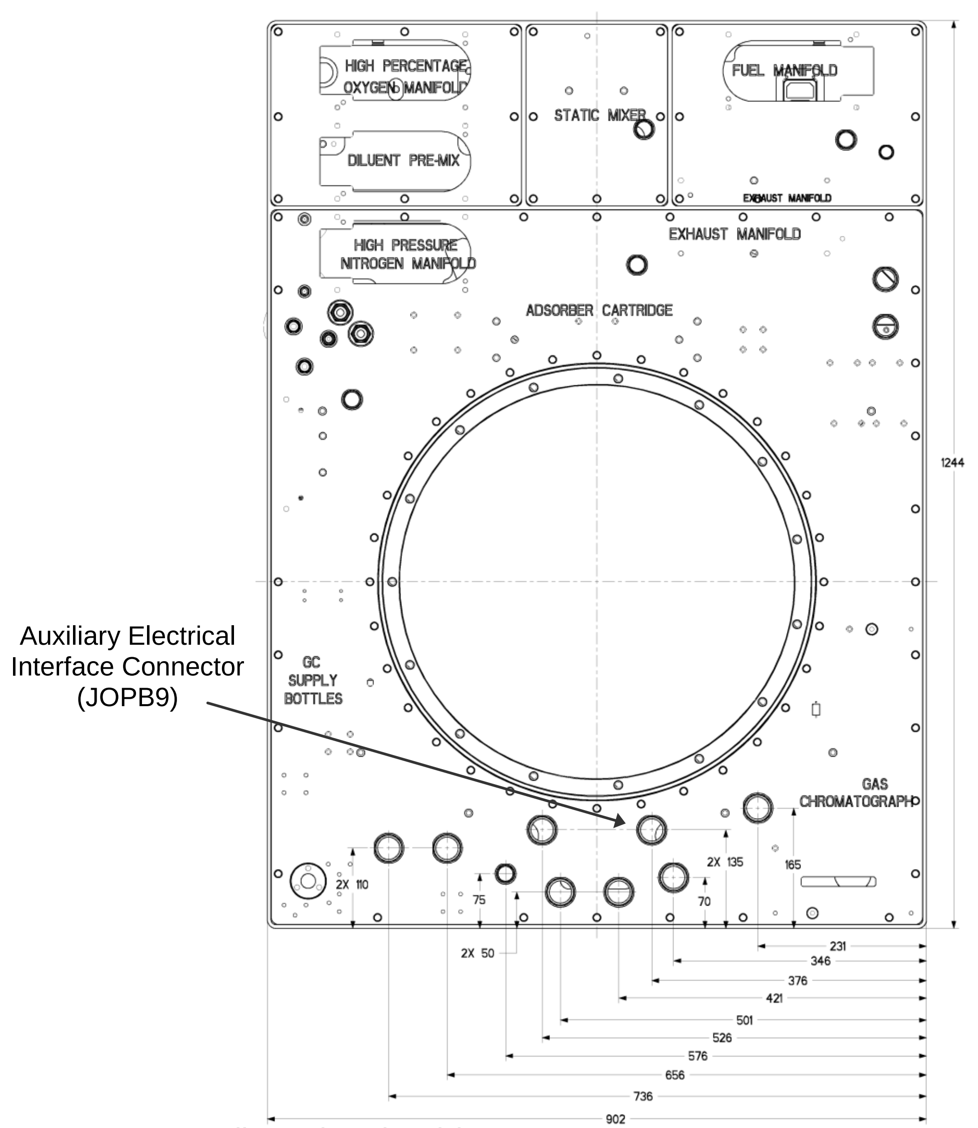
1. All dimensions in millimeters.
2. The relationship of the PIL mounting holes to this package envelope is detailed in FIGURE 11.

FIGURE 13 PIL AVIONICS PACKAGE ENVELOPE

3.1.3 Auxiliary Interface Connectors

3.1.3.1 Auxiliary Electrical Interface Connector

One auxiliary electrical interface connector, JOPB9, on the front of the Optics Bench is available to the payload as shown in FIGURE 14. This connector provides the PD with additional access to all functions provided by the UMLs. The PD shall provide the mating connector, part number D38999/26FH35PC, in order to interface with this connector. The minimum bend radius for a payload-provided cable connected to JOPB9 shall be three times the outside diameter of the cable.

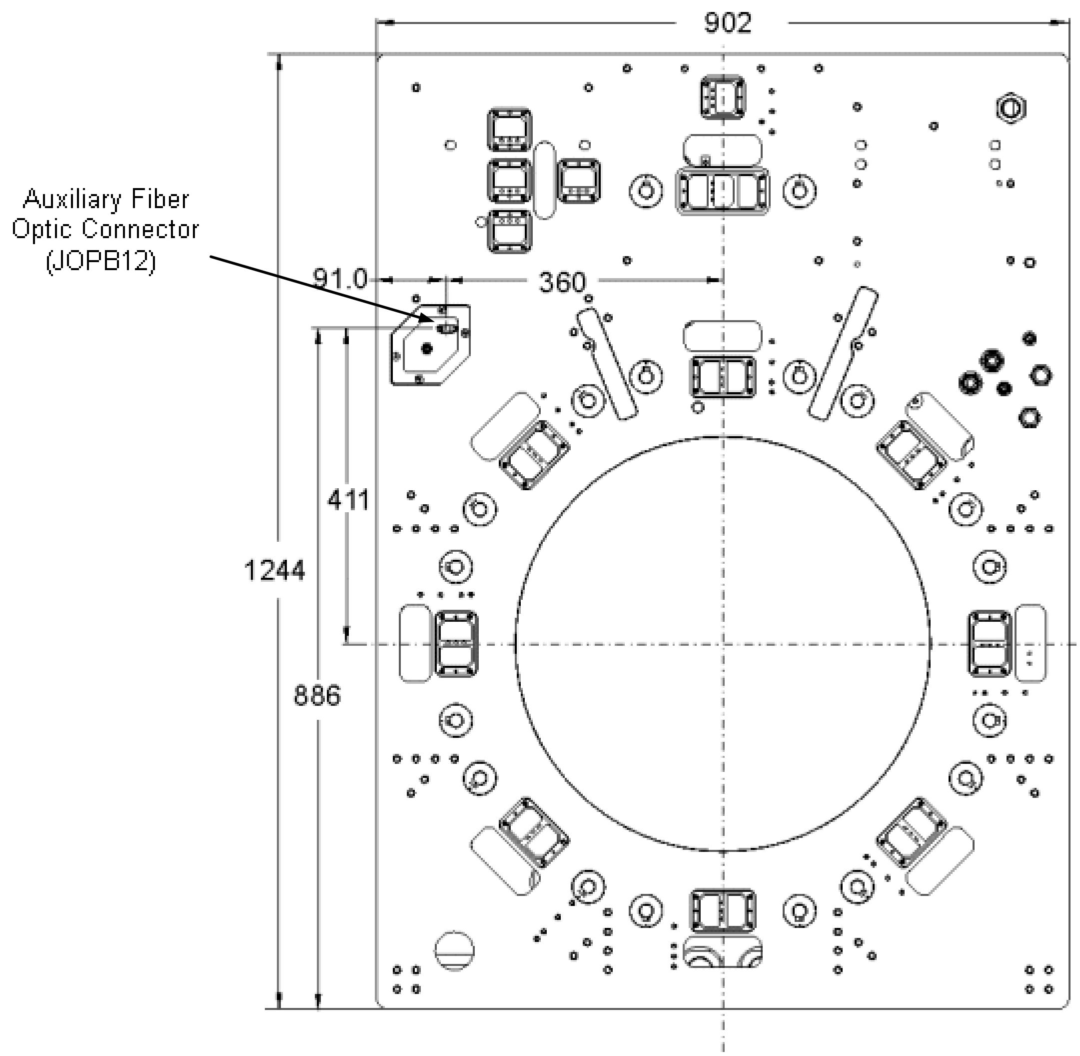


Note: All dimensions in millimeters

FIGURE 14 AUXILIARY ELECTRICAL INTERFACE CONNECTOR

3.1.3.2 Auxiliary Fiber Optic Connector

One auxiliary fiber optic connector, JOPB12, on the rear of the Optics Bench is available to the payload as shown in FIGURE 15. The PD shall provide the mating connector in order to interface with this FC type connector.



Note: All dimensions in millimeters

FIGURE 15 AUXILIARY FIBER OPTIC CONNECTOR

3.1.3.3 Auxiliary Cooling Water Interface

3.1.3.3.1 Optics Bench Cooling Water Quick-Disconnect Fitting

Payload components requiring water cooling in the rear of the Optics Bench shall interface to the moderate temperature water loop Quick-Disconnects (QDs) located on the rear of the Optics Bench. The cooling water inlet and outlet QDs are located at the top right corner of the Optics Bench (looking from the rear) as shown in FIGURE 16. The PD will provide all fluid hoses required to utilize these interfaces.

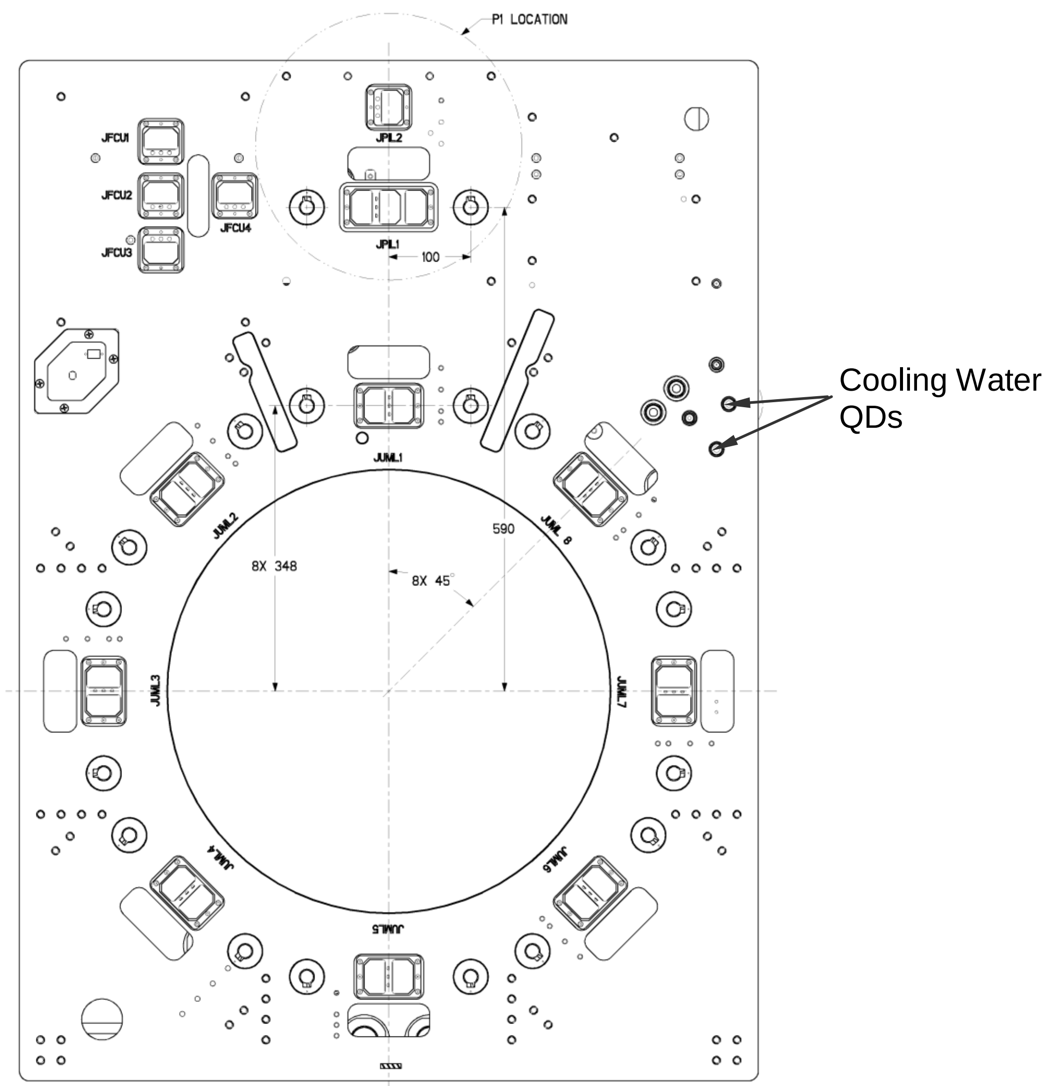


FIGURE 16 COOLING WATER QUICK DISCONNECTS ON THE OPTICS BENCH

The PD shall provide the following mating QDs:

- Water Inlet: PREECE 51410-1-06-1-V-YYXX-C-GY
- Water Outlet: PREECE 51410-1-06-1-V-YYXX-C-G

The payload shall choose XX and YY as provided in TABLE 5 .

TABLE 5 COOLING WATER QD FITTING CONFIGURATIONS AND SIZES

End Fitting Configuration XX	End Fitting Size YY
J – Male O-ring face seal mates with Parker Ultraseal. T – 37º Flared per AS4395 (MS33656) L – 37º Flared bulkhead per AS4396 (MS33657) with TFE groove seal per KC105 S – 37º Flared per AS4395 with TFE groove seal per KC105 TL – 37º Flared bulkhead per AS4396 (MS33657) TF – Modified AS4395, flare removed G – Gamah series 147 threaded flange M – 90º elbow with 37º flared bulkhead AS4396 (MS33657) with TFE groove seal per KC105	04, 06, or 08

3.2 Combustion Chamber

The Combustion Chamber is cylindrical in shape with domed end caps. Four rails are available to mount the payload components in the Combustion Chamber. Axial locating slots are provided in order to position and lock the payload-provided Combustion Chamber insert. Eight windows, with a 115 mm diameter clear aperture, are provided to facilitate science phenomena illumination and imaging. One Rear Access Port is available on the Rear End-Cap to allow payload-unique electrical cables, fluid lines or fiber lines to be passed through the Combustion Chamber walls. A PI Port is available on the Interface Resource Ring (IRR). It provides a small threaded boss that can be used for payload-unique devices that need to pass through the Combustion Chamber. Electrical and fluid connections are established on the inside of the IRR. The Combustion Chamber is shown in FIGURE 17. The Combustion Chamber Maximum Design Pressure (MDP) is 931 kPa (135 psia). The ISS ambient temperature range is 17° – 30° C (62.6° – 86° F).

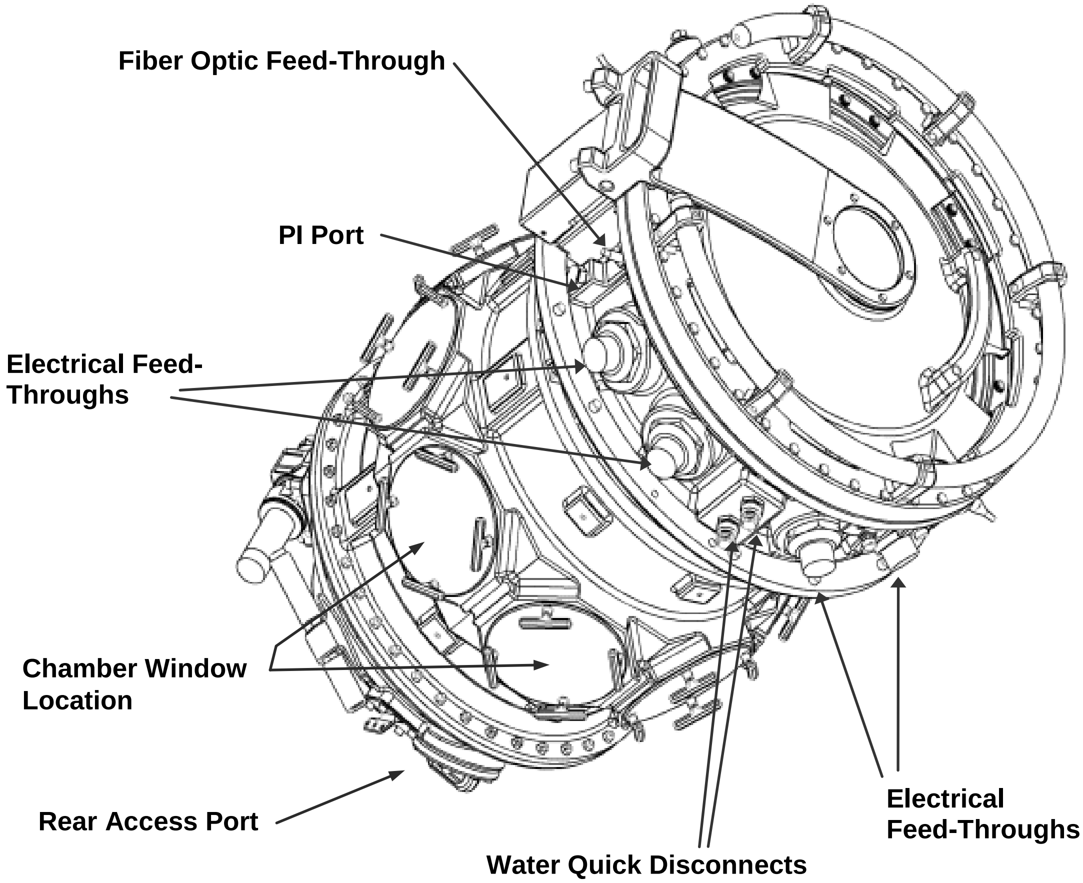


FIGURE 17 COMBUSTION CHAMBER

3.2.1 Interface Resource Ring

The gas QDs are located on the inside of the IRR and are accessible to the payload as shown in FIGURE 18.

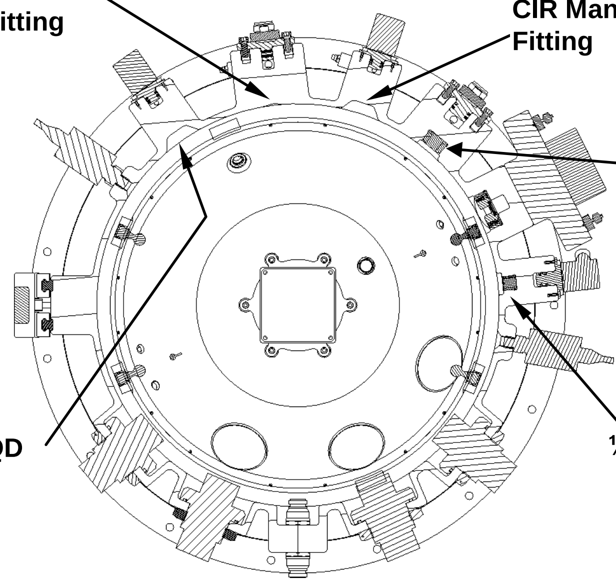


FIGURE 18 IRR GAS INTERFACE QUICK-DISCONNECTS

3.2.1.1 CIR Manifold #3 Interface

3.2.1.1.1 CIR Manifold #3 Quick-Disconnect Fitting

Payload components shall attach to the CIR Manifold #3 (Nitrogen/High Pressure Supply Manifold) with a 3/8-in QD, Preece part number 51128-06-XX-YY-V-D. The payload shall choose XX and YY as specified in TABLE 6 . The CIR-provided mating half of the QD is normally closed and therefore it is required that the payload components physically connect to the QD in order to utilize the interface.

TABLE 6 CIR MANIFOLD #3 QD FITTING CONFIGURATIONS & SIZES

End Fitting Configuration (XX)	End Fitting Size Available (YY)
A – Female Bosses/MS33649 F – Male Flareless/MS33514 G – Male Flareless Bulkhead/MS33515 L – 37° Flared Bulkhead/MS33657 N – Female Pipe Port/ANDI 0053 P – Male Pipe/MS33677 T - 37° Flared Male/MS33656 TF – Modified MS33656, Flare Removed Y - 45° Flared Bulkhead SAE J513/514	04, 06, 08

3.2.1.1.2 CIR Manifold #3 Quick-Disconnect Fitting Additional Controls

Payload components interfacing with the CIR Manifold #3 QD, as shown in FIGURE 18, shall provide an additional means of pressure control.

3.2.1.2 Static Mixer Gas Supply Interface

3.2.1.2.1 Static Mixer Gas Supply Quick-Disconnect Fitting

Payload components shall attach to the Static Mixer Gas Supply through a ½-in QD, Preece part number 941-08-2-XX-08-V-YY. The payload shall choose XX and YY as specified in TABLE 7 . The Static Mixer Gas Supply is normally opened, and therefore it is not necessary for the payload components to physically connect to these QDs in order to use this interface.

TABLE 7 STATIC MIXER GAS SUPPLY QD FITTING CONFIGURATIONS & KEYING NUMBERS

End Fitting Configuration (XX)	Keying Number (YY)
A – Female Bosses/MS33649 F – Male Flareless/MS33514 G – Male Flareless Bulkhead/MS33515 L – 37° Flared Bulkhead/MS33657 N – Female Pipe Port/ADNI 0053 P – Male Pipe/MS33677 T - 37° Flared Male/MS33656 TF – Modified MS33656, Flare Removed D – Male Dyna Tube/MIL-F-85720	045 – 0°+45° BLUE 135 – 0+135° YELLOW

3.2.1.3 CIR Manifold #4 Interface

3.2.1.3.1 CIR Manifold #4 Quick-Disconnect Fitting

Payload components shall interface to CIR Manifold #4 (Fuel/Premixed Fuel Supply Manifold)through a 1/4-in QD, Preece part number 941-04-2-XX-04-V-YY. The mating half of the QD provided by the CIR is normally closed and therefore it is required that the payload components physically connect to the QD in order to utilize the interface. The payload shall choose XX and YY as specified in TABLE 8

TABLE 8 CIR MANIFOLD #4 QD FITTING CONFIGURATIONS & KEYING NUMBERS

End Fitting Configuration (XX)	Keying Number (YY)
A – Female Bosses/MS33649 F – Male Flareless/MS33514 G – Male Flareless Bulkhead/MS33515 L – 37° Flared Bulkhead/MS33657 N – Female Pipe Port/ANDI 0053 P – Male Pipe/MS33677 T - 37° Flared Male/MS33656 TF – Modified MS33656, Flare Removed D – Male Dyna Tube/MIL-F-85720	045 – 0°+45° BLUE 090 – 0°+90° BLACK 135 – 0°+135° YELLOW 180 – 0°+180° PURPLE

3.2.1.4 Gas Chromatograph Interface

3.2.1.4.1 Gas Chromatograph Quick-Disconnect Fitting

Payload components shall interface to the Gas Chromatograph (GC) interface through a ¼-in QD, Cole Parmer part number U-31403-27. This QD is normally open and therefore it is not necessary for the payload components to physically connect to this QD in order to use this interface. This connection is only required if the payload requests a GC sample to be taken from a specific location inside the Combustion Chamber.

3.2.1.5 Cooling Water Interface

3.2.1.5.1 Combustion Chamber Cooling Water Quick-Disconnect Fitting

Payload components requiring water-cooling shall interface to the moderate temperature water loop QDs located on the inside of IRR. The cooling water inlet and outlet QDs are located at the 6 o'clock position as shown in FIGURE 19. The PD will provide all fluid hoses required to utilize these interfaces.

The PD shall provide the following mating QDs:

- Water Inlet: PREECE 51410-1-06-1-V-XXYY-C-GY
- Water Outlet: PREECE 51410-1-06-1-V-XXYY-C-G

The payload shall choose XX and YY as specified in TABLE 9 .

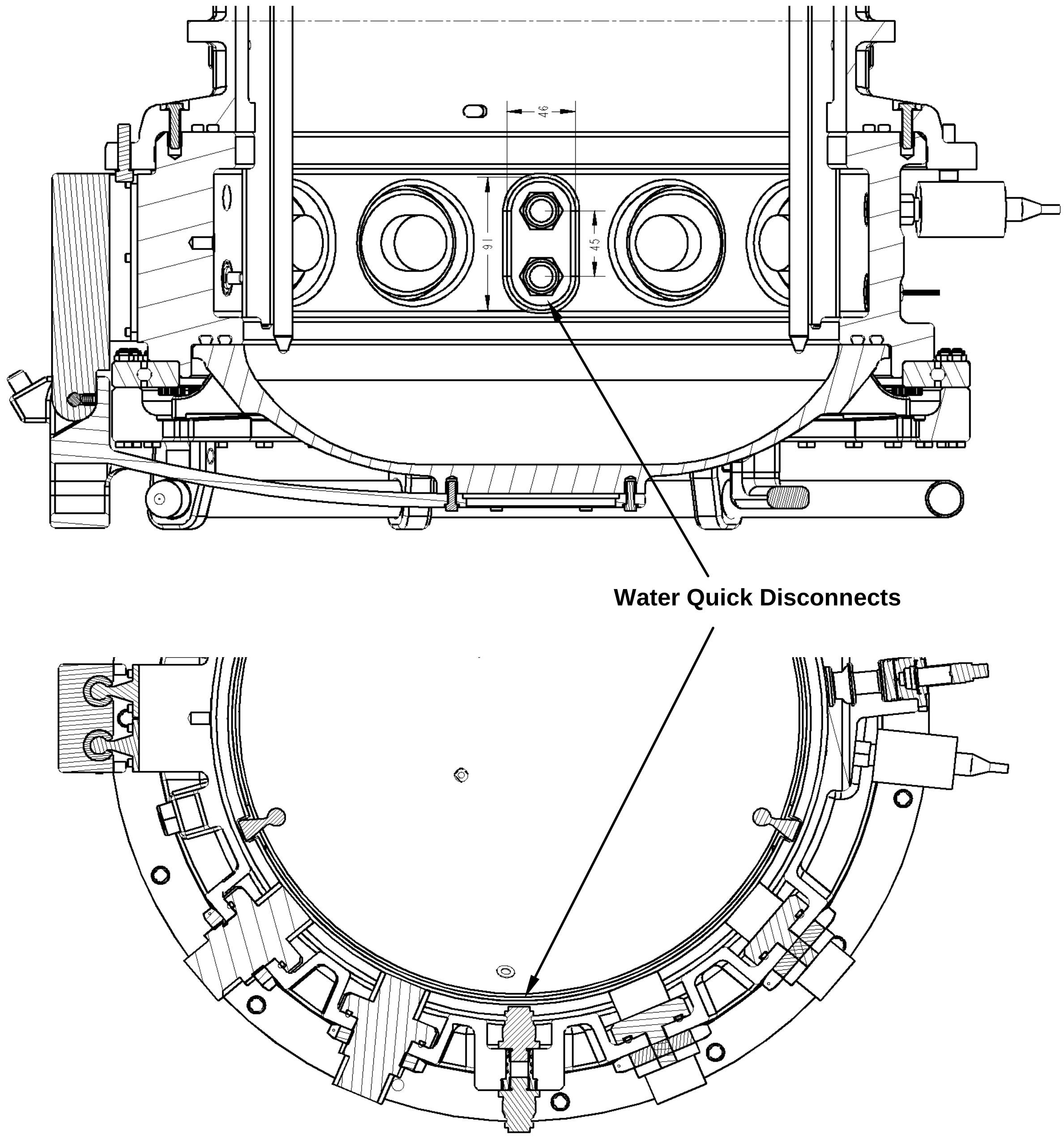


FIGURE 19 WATER QUICK DISCONNECTS ON THE IRR

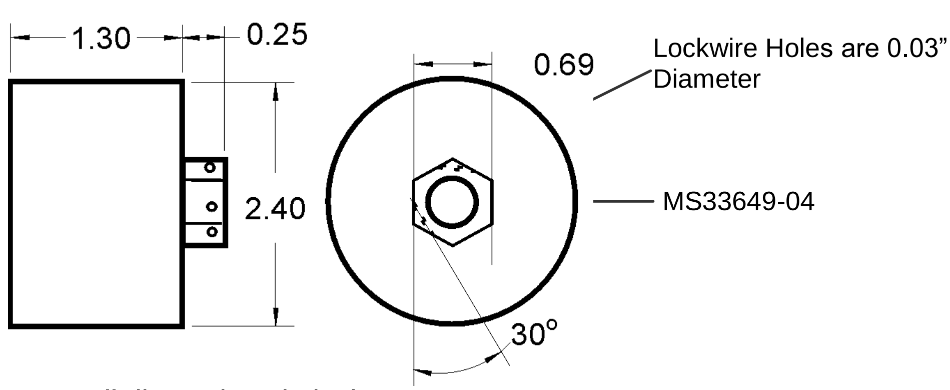
TABLE 9 COOLING WATER QD FITTING CONFIGURATIONS AND SIZES

End Fitting Configurations XX	End Fitting Size YY
J – Male O-ring face seal mates with Parker Ultraseal **T** – 37º Flared per AS4395 (MS33656) **L** – 37º Flared bulkhead per AS4396 (MS33657) with TFE groove seal per KC105 **S** – 37º Flared per AS4395 with TFE groove seal per KC105 **TL** – 37º Flared bulkhead per AS4396 (MS33657) **TF** – Modified AS4395, flare removed **G** – Gamah series 147 threaded flange **M** – 90º elbow with 37º flared bulkhead AS4396 (MS33657) with TFE groove seal per KC105	04, 06, or 08

3.2.1.6 Government Furnished Accumulator

Payload components that are charged with cooling water shall compensate for thermal expansion during transportation to/from the ISS and while on-board the ISS when not connected to the rack, as specified in section 5.7 of this document. Payload components may utilize the standard accumulators provided by the FCF as Government Furnished Equipment (GFE) to meet this requirement. Payload components utilizing the GFE Accumulator shall be compatible with the following characteristics:

1. The accumulator has a capacity of 2 cubic in (0.03 liters) and a dry weight of 0.45 kg (1.00 lb). The accumulator is shown in FIGURE 20.
2. The fluid and mechanical interface for the accumulator is an inlet port per MS33649-04. The inlet port provides two holes for the installation of a lock-wire.



Note: All dimensions in inches

FIGURE 20 GFE ACCUMULATOR ENVELOPE

3.2.1.7 Electrical Feed-Throughs

The PD has access to four electrical feed-throughs and one fiber optic feed-through on the inside of the IRR. These connectors are designated as JCTC5, JCTC6, JCTC7, JCTC8 and JCTC10. The locations of the electrical feed-throughs and the IRR connector keying are shown in FIGURE 21. The fiber optic feed-through is shown in FIGURE 22. Payload components that interface with these connectors shall use mating connectors with the following part numbers:

- PCTC5 - D38999/26FH35PN
- PCTC6 - D38999/26FH55PA
- PCTC7 - D38999/26FH21PB
- PCTC8 - D38999/26FH35PC
- PCTC10 – Fiber Optic Type FC

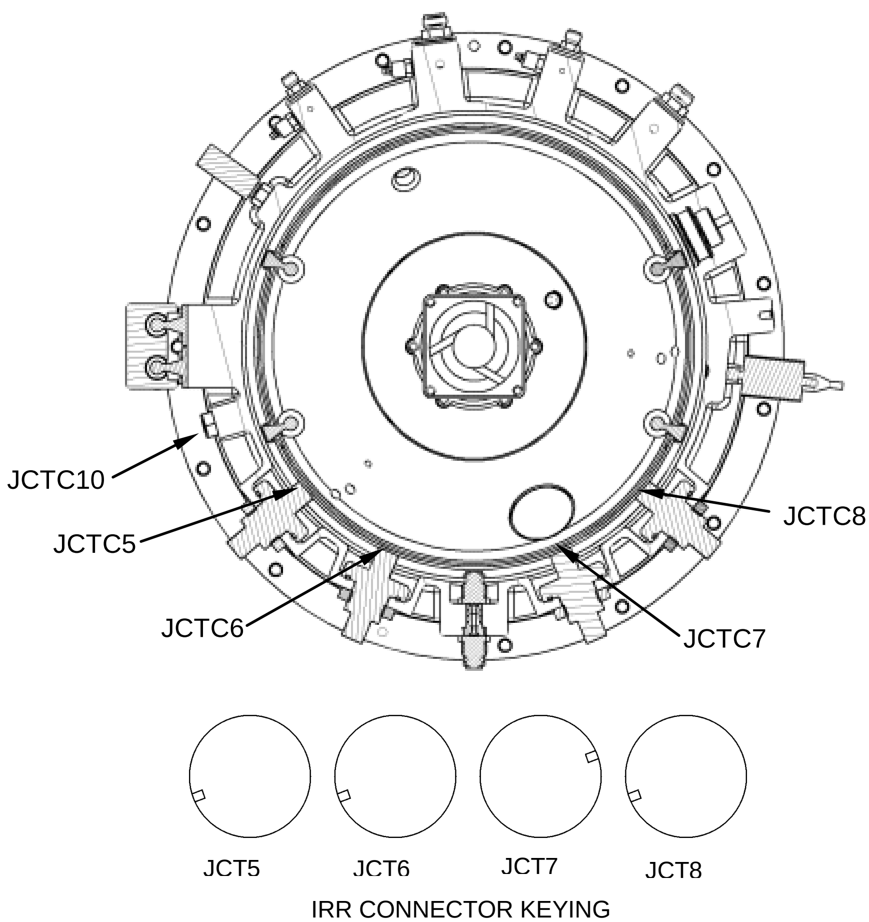


FIGURE 21 IRR ELECTRICAL FEED-THROUGHS

3.2.1.8 Principal Investigator Port

The PI Port shall be used for payload components that must pass through the Combustion Chamber wall. The location of this port is shown in FIGURE 22.

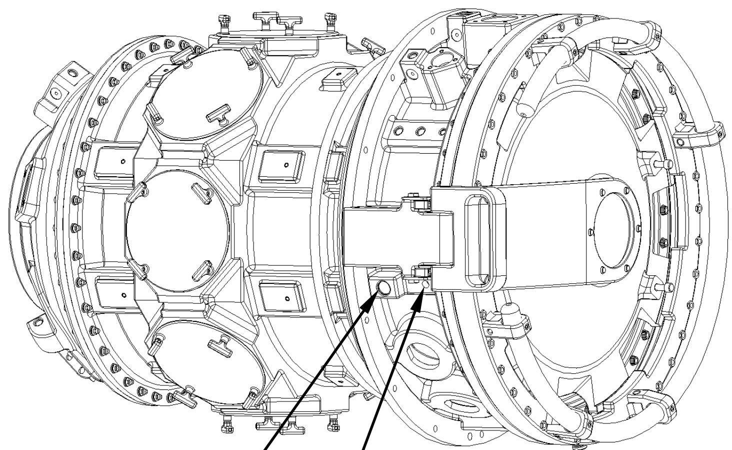


FIGURE 22 PI PORT AND FIBER OPTIC FEED-THROUGH

3.2.1.8.1 Principal Investigator Port Safety Requirements

Payload components that utilize the PI Port shall meet the requirements for fracture critical components stated in section 4.9.2 of this document. The payload components shall be designed to be compatible with the MDP of the Combustion Chamber described in section 3.2 of this document.

3.2.1.8.2 Principal Investigator Port Threaded Boss Fitting

The PI Port provides a threaded boss per MS33649-08. Payload components that interface with this boss shall utilize an o-ring pressure fitting per MS33656-08.

3.2.1.8.3 Principal Investigator Port Threaded Boss Fitting Envelope

Payload components that utilize the PI Port shall be compatible with the envelope shown in FIGURE 23.

<TBD 03-01>

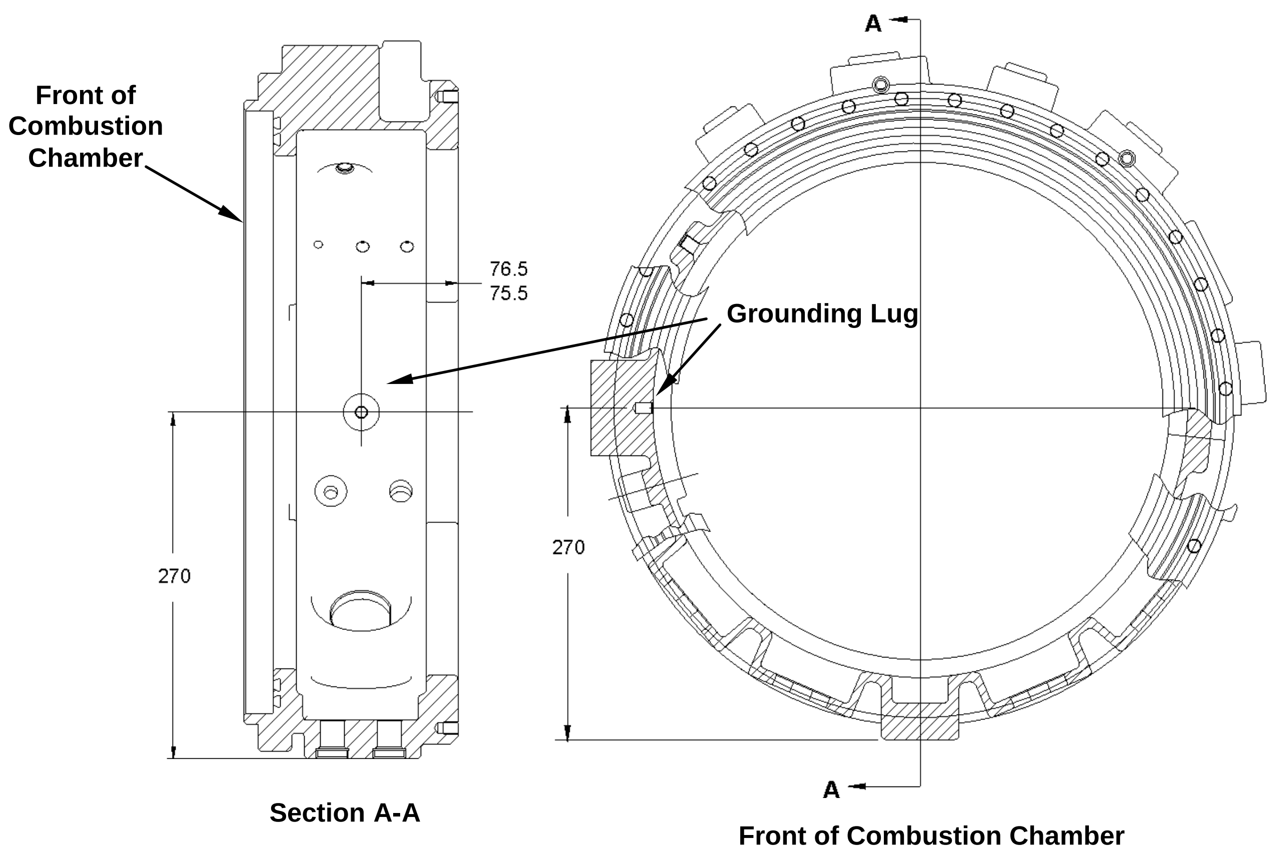
FIGURE 23 PI PORT ENVELOPE

3.2.1.9 Vacuum Exhaust Port

The Vacuum Exhaust Port interface is a stainless steel threaded insert located below the vent valve inside the IRR, as shown in FIGURE 18. Payload components shall be compatible the 1.75 inch major diameter - 0.125 pitch - 0.25 inch long, class 3g, general purpose, single blunt start, ACME threaded insert. Any connector that interfaces with the Vacuum Exhaust Port shall contain a 100-micron absolute filter. The existing CIR IRR Vent Filter shall be removed from the Vacuum Exhaust Port and stowed before attaching any payload components to the port. The diameter of the connector shall not exceed 55 mm.

3.2.1.10 Combustion Chamber Grounding Interface

Payload components that utilize the Combustion Chamber grounding interface shall utilize the ¼ - 28 UNF-3B threaded mounting hole as shown in FIGURE 24. The thread depth shall not exceed 11 mm (.43 in) and shall utilize a spot face not to exceed 28 mm (1.10 in).



Note: All dimensions in millimeters

FIGURE 24 COMBUSTION CHAMBER GROUNDING INTERFACE

3.2.2 CIR Chamber Fan Interface

The CIR Chamber Fan is used to facilitate homogenous mixing of the Combustion Chamber gaseous environment. When the payload components interfere with the CIR Chamber Fan envelope as shown in FIGURE 35, or use the volume occupied by the fan, the CIR Chamber Fan can be replaced on-orbit with the CIR Rear End Cap Plug.

3.2.3 Rear Access Port

Payload components have access to the Rear Access Port on the Rear End-Cap of the Combustion Chamber. The location of this port is shown in FIGURE 25. The Rear Access Port is normally plugged, but the plug can be replaced on-orbit with a payload-provided feed-through that shall conform to the interface requirements as shown in FIGURE 26.

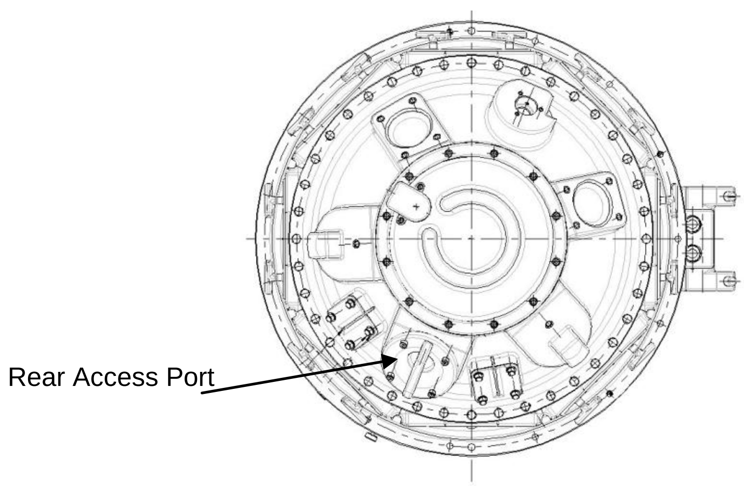
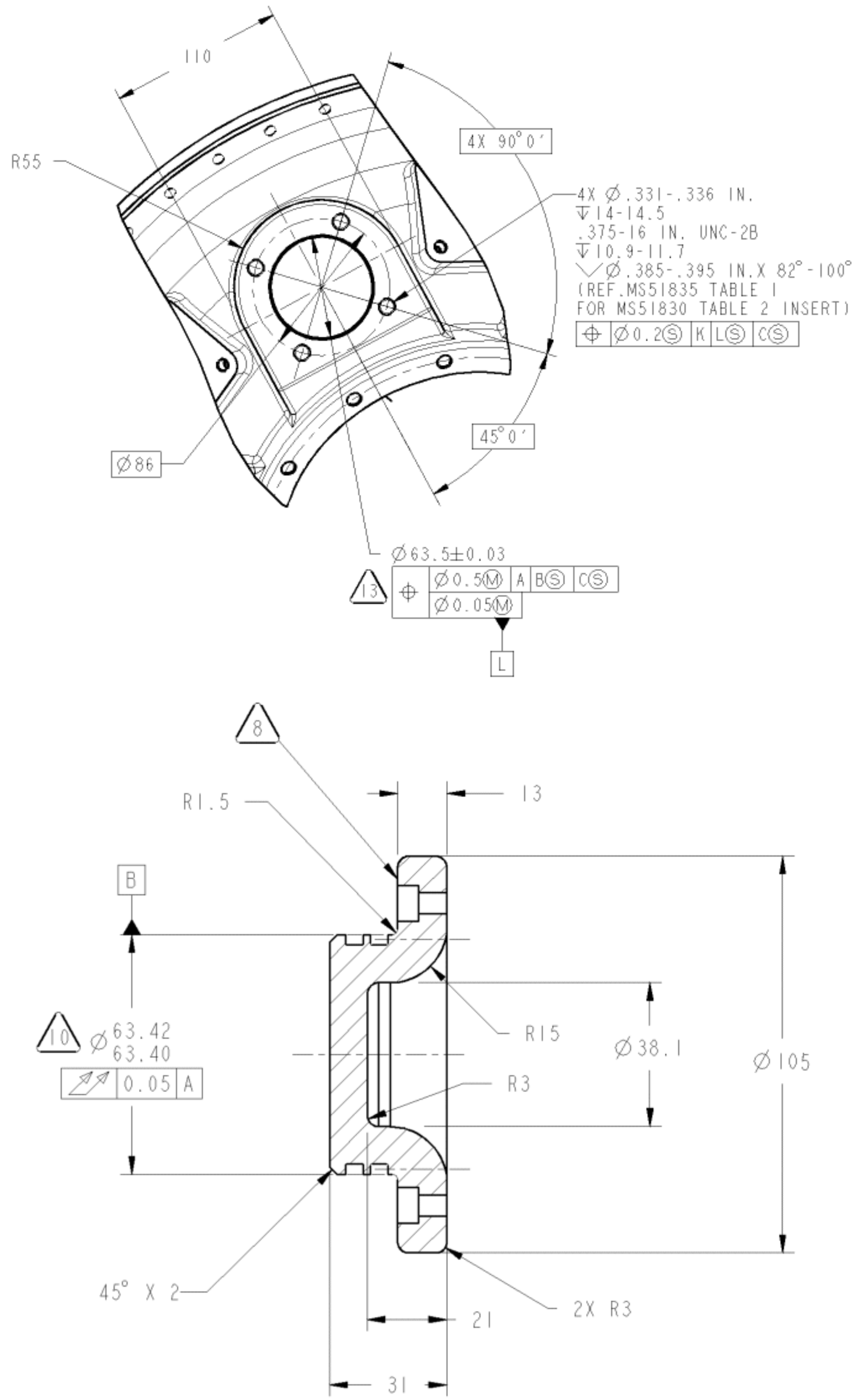


FIGURE 25 REAR ACCESS PORT LOCATION ON THE REAR END-CAP



Note: All dimensions in millimeters

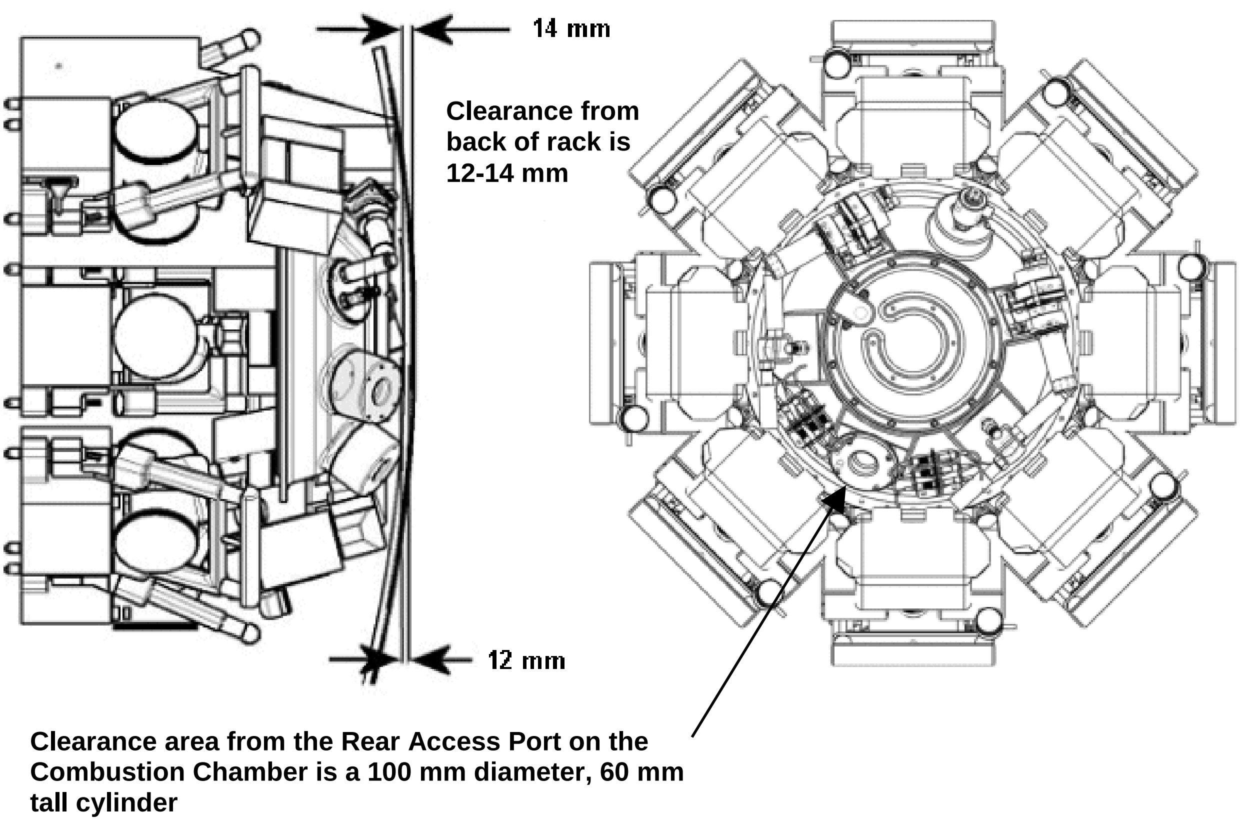
FIGURE 26 REAR ACCESS PORT INTERFACE DETAILS

3.2.3.1 Rear Access Port Safety Requirements

The payload-provided feed-through shall meet the requirements for fracture critical components as described in section REF _Ref2130788 \r \h 4.9.2 of this document. The feed-through shall be designed to be compatible with the MDP of the Combustion Chamber as described in section 3.2 of this document.

3.2.3.2 Rear Access Port Envelope

The payload-provided feed-throughs that utilize the Rear Access Port shall be compatible with the envelope shown in FIGURE 27.



Note: All dimensions in millimeters

FIGURE 27 REAR ACCESS PORT ENVELOPE

3.2.4 Window Ports

The eight CIR windows may be replaced with payload-provided windows or feed-throughs. The FCF-provided replaceable Window Assembly is shown in FIGURE 28. The standard window material is Sapphire (Al_20_3) that has a transmission wavelength of 0.25 – 5.0 µm as defined in CIR-SCD-0300.

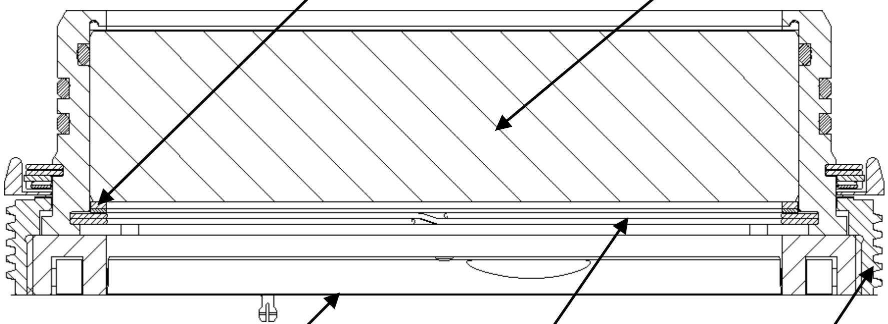


FIGURE 28 REPLACEABLE WINDOW ASSEMBLY

3.2.4.1 Window Assembly General Requirements

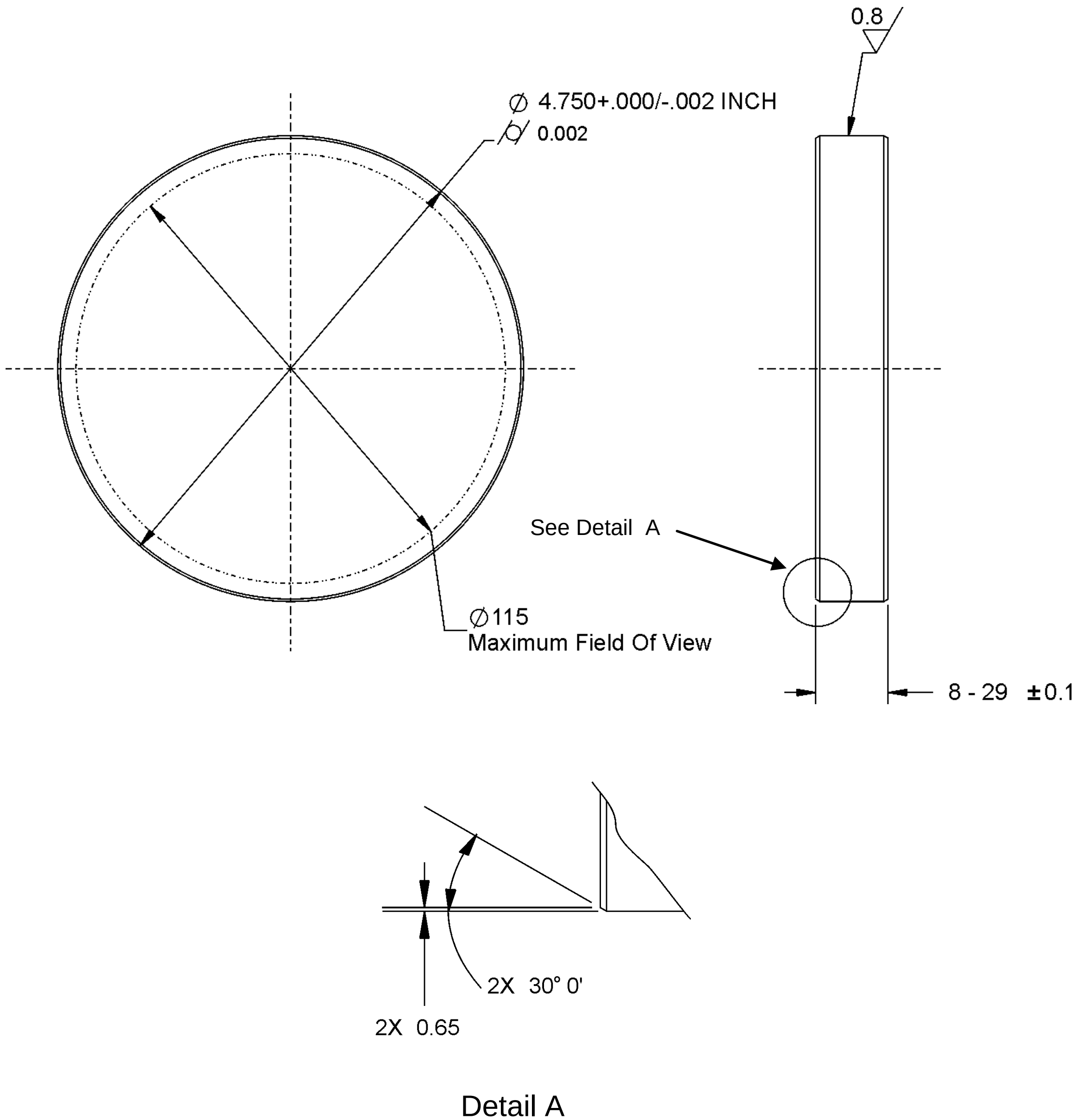
Any of the eight CIR windows may be replaced with a payload-provided window. The PD shall provide the window material per the requirements shown in FIGURE 29. The thickness shown in FIGURE 29 has been calculated for a Sapphire window. Thickness will vary based on the window material selected by the PD. The imaging, illumination and laser devices utilizing the windows shall be compatible with a maximum field of view of 115 mm.

3.2.4.2 Window Assembly Safety Requirements

The payload-provided windows shall meet the requirements for fracture critical components as stated in section REF _Ref2130788 \r \h 4.9.2 of this document. The windows shall be designed to be compatible with the MDP of the Combustion Chamber as described in section 3.2 of this document.

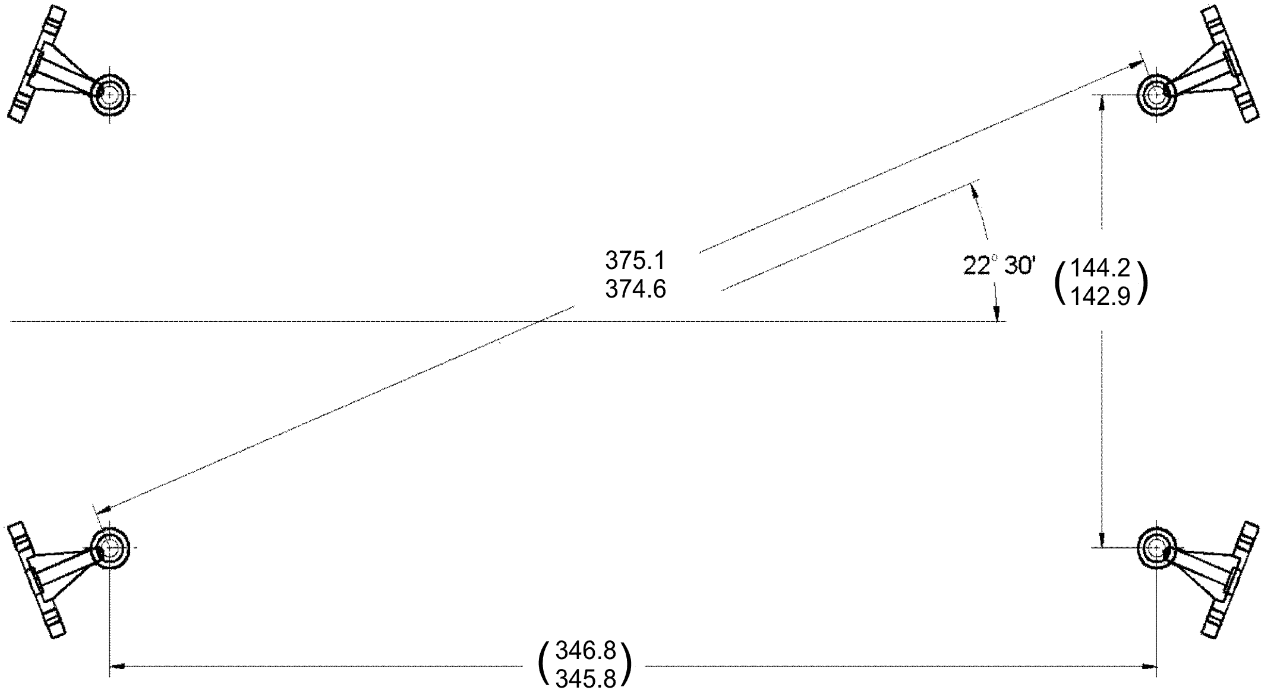
3.2.5 Mounting Rails

Payload components shall attach to at least two rails located inside the Combustion Chamber. The rails are made of 455 CRES 1050 and are positioned 22.5° above and below the horizontal axis of the Combustion Chamber. Rail-to-rail tolerances are shown in FIGURE 30. Payload components shall be compatible with a rail parallelism of 0.1 mm (0.004 in) from the front of the Combustion Chamber to the rear of the Combustion Chamber. An overview of the rails is shown in FIGURE 31. The detailed design information for the rails is shown in FIGURE 32.



Note: All dimensions in millimeters unless otherwise noted

FIGURE 29 WINDOW REQUIREMENTS



Notes:

1. All dimensions in millimeters unless otherwise noted.
2. Dimensions in parenthesis were derived from the manufacturing tolerances of the Combustion Chamber and the rails.

FIGURE 30 RAIL-TO-RAIL TOLERANCES

Payload components shall be designed with a locking mechanism to ensure that they will be held in place during any reconfiguration of the Combustion Chamber. Payload components shall be compatible with the hard stops located 217 mm (8.54 in) from the center of the windows toward the rear of the Combustion Chamber. These hard stops shall not be used as a locating device. The hard stops are 25.4 mm (1.0 in) diameter 6061-T6 Aluminum with a thickness of 1.6 mm (0.063 in). They are present to prevent the payload components from impacting the fan and other instrumentation in the Rear End Cap. The hard stops are 29 mm diameter aluminum disks attached to the rear end of each rail. Window center-to-center of electrical connectors is 352.3 mm (13.87 in). Accuracy for insert centering with respect to the center of the Combustion Chamber is +/- 0.13 mm (0.005 in).

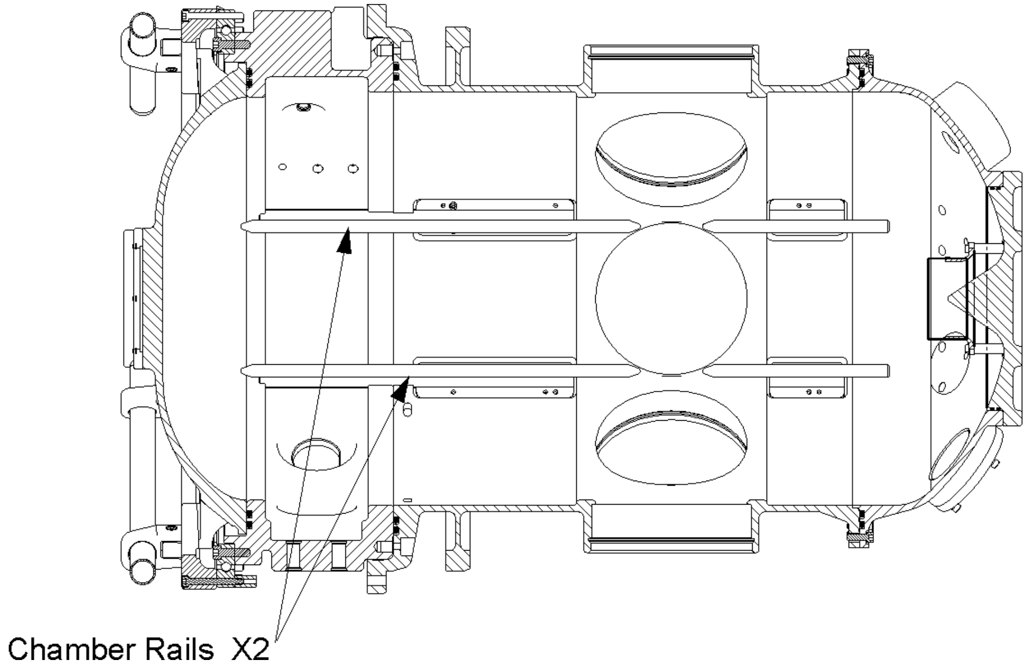
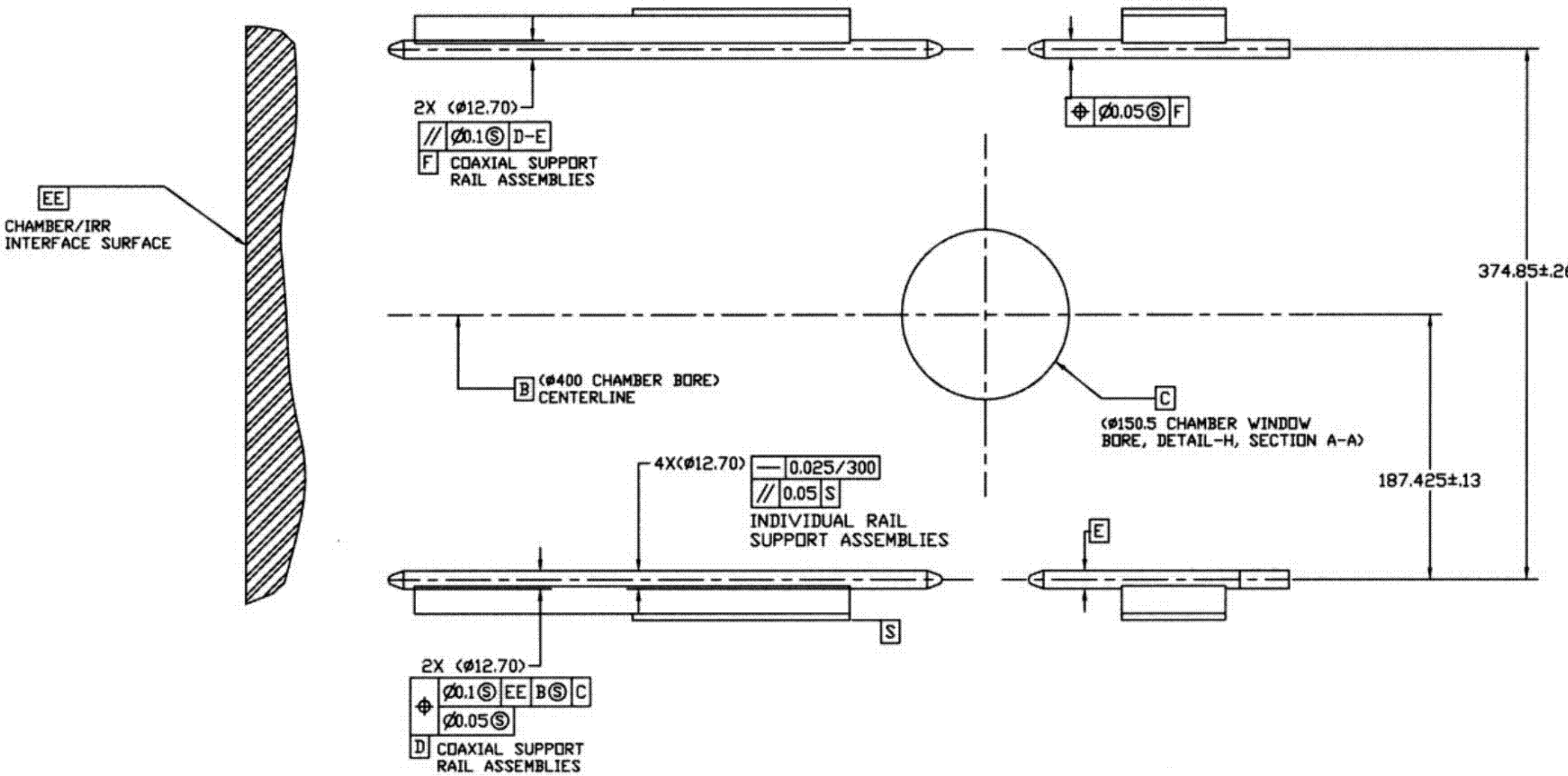


FIGURE 31 COMBUSTION CHAMBER MOUNTING RAIL CONFIGURATION

3.2.6 Axial Locating Slots

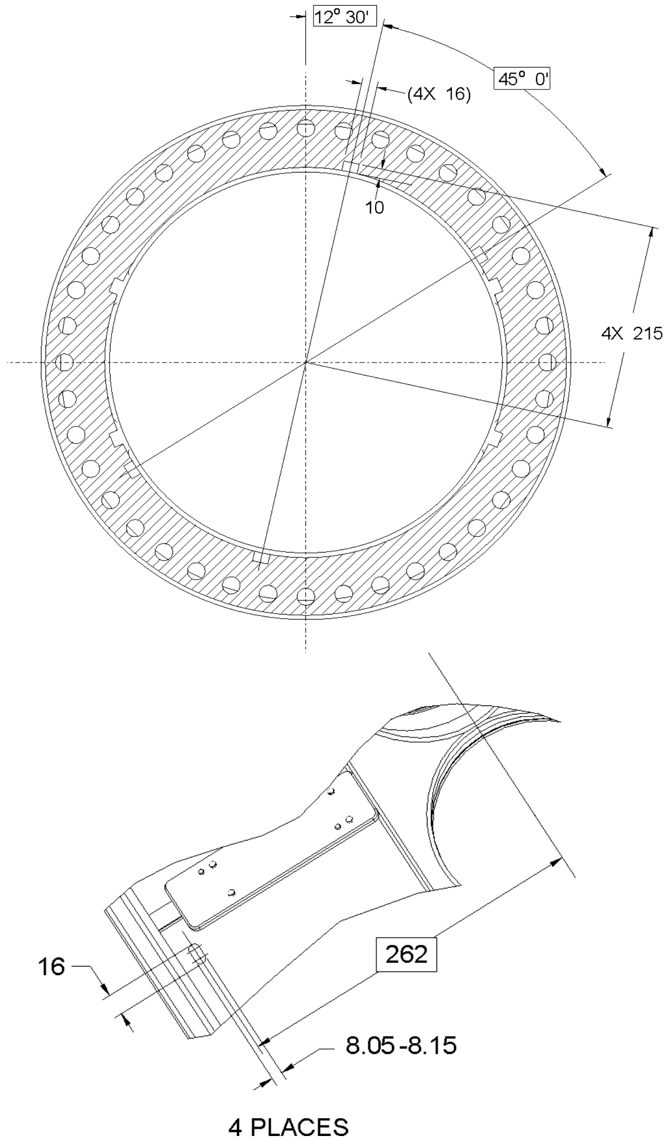
Four axial locating slots are available to provide alignment of the payload components to the windows. Payload components that utilize these slots shall be compatible with the slot locations and geometries shown in FIGURE 33.

The distance from the axial locating slots to the center of the Combustion Chamber windows is 262 mm+/- 0.1 mm. The payload components shall be compatible with this distance.



Note: All dimensions in millimeters unless otherwise noted

FIGURE 32 COMBUSTION CHAMBER MOUNTING RAILS



Note: All dimensions in millimeters

FIGURE 33 AXIAL LOCATING SLOTS

3.2.7 Vacuum Exhaust System Interface

Combustion byproducts are typically vented to the ISS Vacuum Exhaust System (VES) through the CIR Exhaust Vent Package (EVP). Payload components typically do not have a physical connection to the EVP since the Combustion Chamber internal volume is directly plumbed to the EVP. If the payload accesses the VES directly, the payload components shall be compatible with the Vacuum Exhaust Port as described in section 3.2.1.9 of this document.

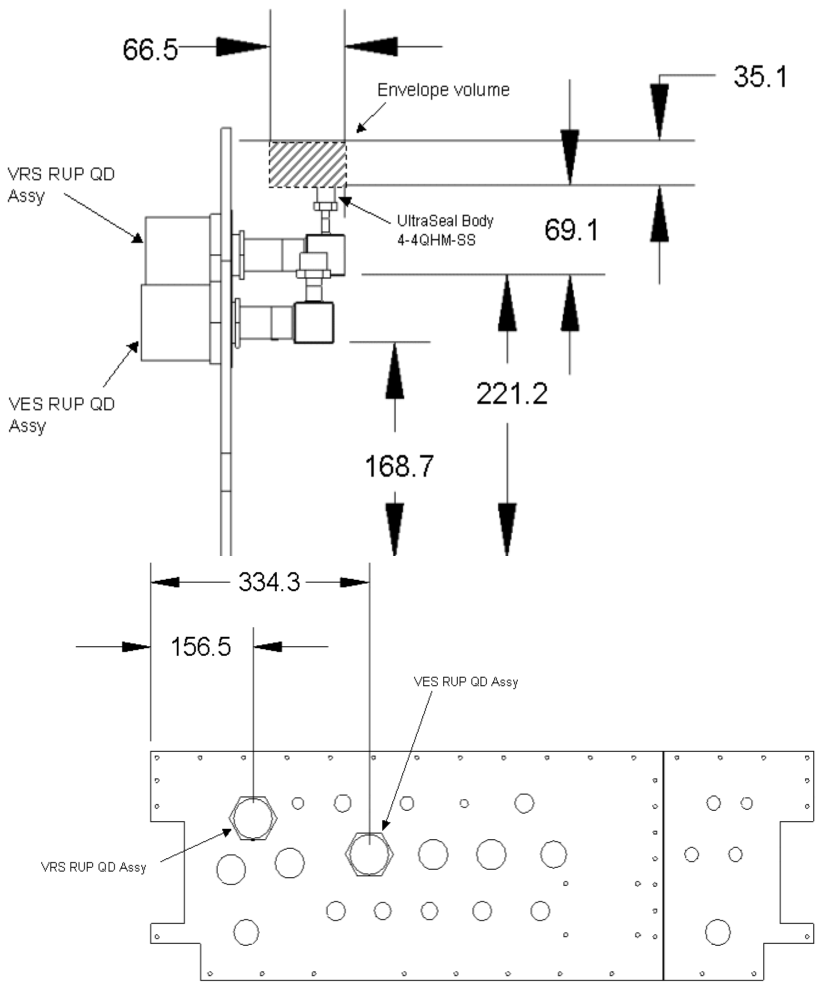
3.2.8 Vacuum Resource System Interface

3.2.8.1 Vacuum Resource System Quick-Disconnect Fitting

A view of the Rack Utility Interface Panel (UIP) from the back with VES or Vacuum Resource System (VRS) QDs installed is shown in FIGURE 34. The VRS line consists of the VRS Rack UIP QD Assembly (a Boeing QD, a reducing elbow, and an Ultraseal Body 4-4QHM-SS) and a cap. Payload components that interface with the VRS shall be compatible with this QD assembly.

3.2.8.2 Vacuum Resource System Quick-Disconnect Fitting Envelope

Payload components that interface with the VRS shall be compatible with the VRS QD envelope as shown in FIGURE 34.



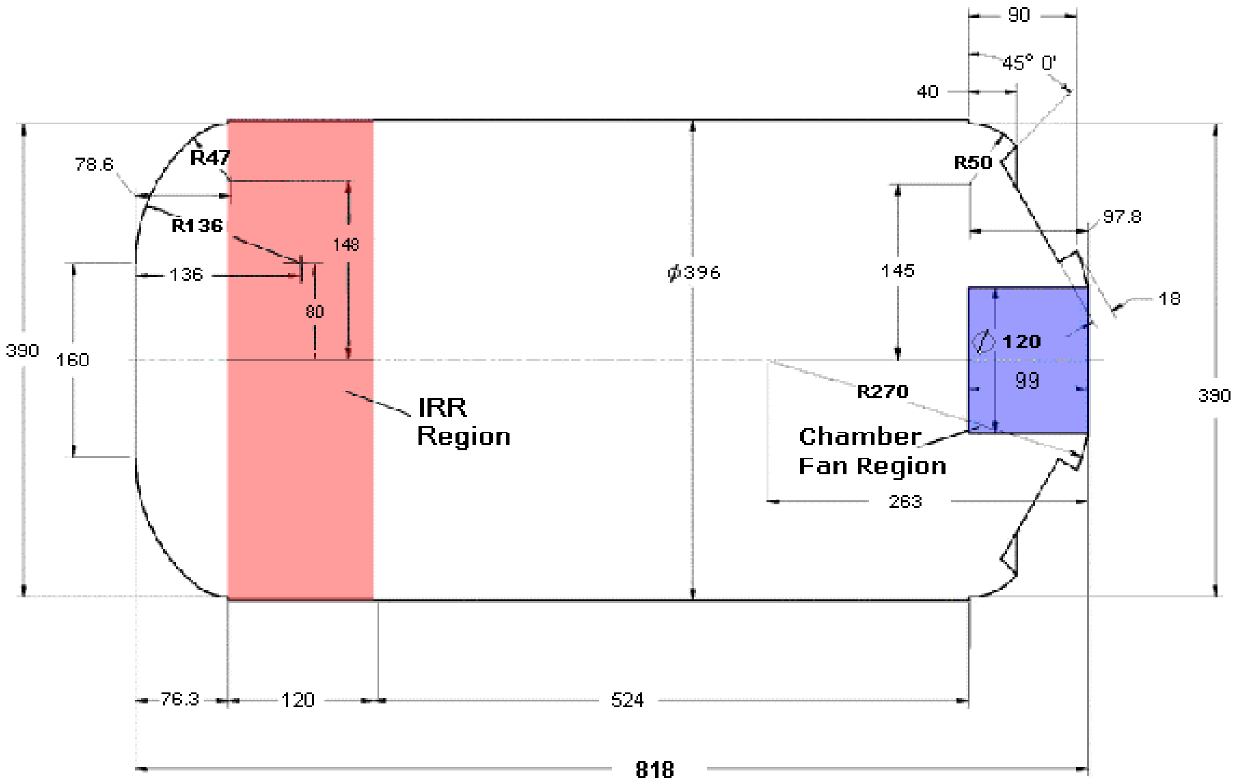
Note: All dimensions in inches

FIGURE 34 VACUUM RESOURCE SYSTEM INTERFACE DETAILS

3.2.9 Internal Volume Envelope

3.2.9.1 Internal Volume with CIR Chamber Fan

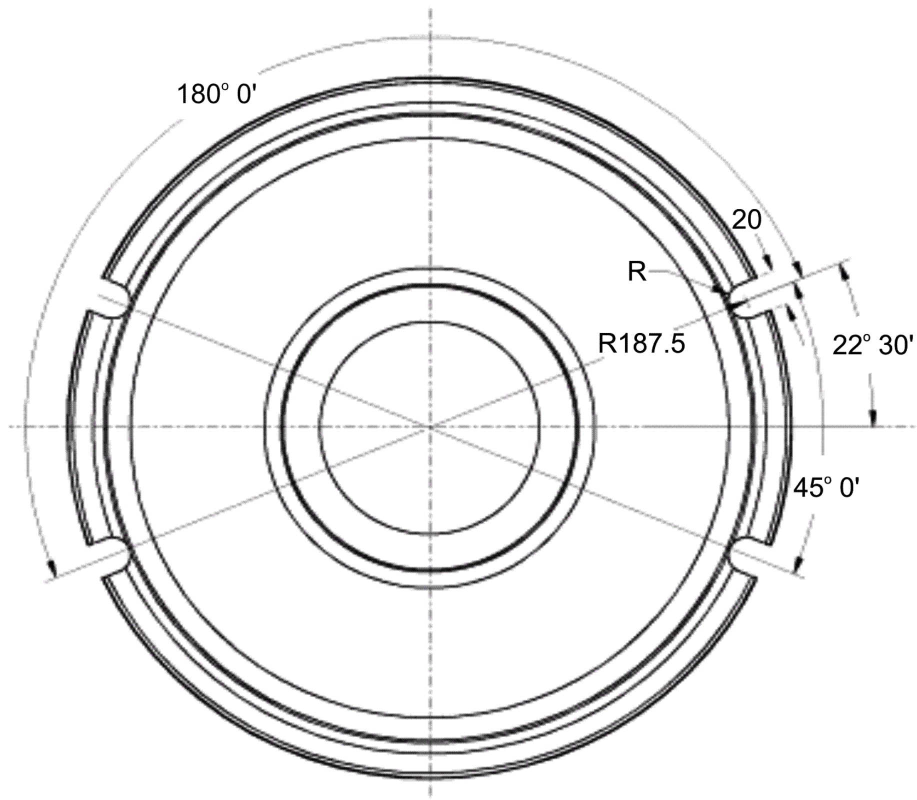
The payload components that use the CIR Chamber Fan shall comply with the envelope volume requirements specified in FIGURE 35 and FIGURE 36.



Notes:

1. The area shown as the IRR is where all data, power, fluid, and optional connections are performed. The area required to make these connections must be taken into account during design.
2. The area shown as the Chamber Fan Region represents the volume that must remain clear if the chamber insert will utilize the fan already installed in the chamber.
3. All dimensions in millimeters unless otherwise noted.

FIGURE 35 COMBUSTION CHAMBER ENVELOPE AVAILABLE TO THE INSERT



Note: All dimensions in millimeters

FIGURE 36 END-VIEW COMBUSTION CHAMBER ENVELOPE

3.2.9.2 Internal Volume with CIR Rear End Cap Plug

The payload components that use the CIR Rear End Cap Plug in lieu of the CIR Chamber Fan shall comply with the envelope requirements specified in FIGURE 35. The envelope volume requirements are increased by the volume of the Chamber Fan Region as shown in FIGURE 35 (i.e. disregard figure note 2).

3.2.9.3 Internal Volume Requirements When Using CIR Manifold #3

PDs that utilize CIR Manifold #3 shall determine the free volume of the Combustion Chamber after the Chamber Insert Assembly has been installed. The bottle attached to CIR Manifold #3 shall be sized to prevent over pressurization if the entire bottle is emptied into the Combustion Chamber.

3.3 Fuel/Oxidizer Management Assembly

Bottle assemblies containing payload-provided gas mixtures will be connected to the FOMA supply manifolds for introduction into the Combustion Chamber during payload operation. Bottled check gases and carrier gases will be attached to the GC Gas Supply Package.

3.3.1 FOMA Supply Manifold Gas Mixture Requirements

The payload-unique gas mixtures shall be supplied using the standard CIR bottle sizes of 1.00, 2.25 and 3.80 liters. Bottles are labeled and have a color-coded keyed plate to prevent inadvertent installation of an incorrect gas bottle. The allowable combination of bottles used at the various FOMA supply manifolds is provided in TABLE 10 .

TABLE 10 ALLOWABLE GAS BOTTLE SIZES/COMBINATIONS

Manifold	Gas Bottles		
	1.00 Liter	2.25 Liter	3.80 Liter
CIR Manifold #1 (Diluent/Premixed Gas Supply Manifold)	X	X	X
CIR Manifold #2 (High Percentage Oxygen Supply Manifold)	X	X (2)	X (2)
CIR Manifold #3 (Nitrogen/High Pressure Supply Manifold)	X	X	X
CIR Manifold #4 (Fuel/Premixed Fuel Supply Manifold)	X	(3)	(3)

Notes:

(1) The use of this bottle in CIR Manifold #1 will preclude the use of the CIR Manifold #4.
(2) See TABLE 11 .
(3) The use of this bottle in CIR Manifold #4 will preclude the use of the CIR Manifold #1.

3.3.1.1 Gas Bottle Maximum Pressure

The payload-unique gas mixtures shall be limited to a maximum charged pressure of 14 MPa (2,000 psia) at 45º C.

3.3.1.2 Gas Bottle Maximum Oxygen Concentration

The payload-unique gas mixtures shall be limited to a maximum allowable oxygen concentration, based on bottle size, as provided in TABLE 11 .

TABLE 11 MAXIMUM OXYGEN CONCENTRATION

Gas Bottle Size Liters	Maximum Oxygen Concentration Volume %
1.00	85(1)
2.25	50(1)
3.80	30(2)

Notes:

(1) These bottles can only be used in CIR Manifold #2.
(2) This bottle type can be used in any supply manifold EXCEPT CIR Manifold #4.

3.3.2 GC Gas Supply Package Carrier and Check Gas Requirements

The PD shall be responsible for providing GC check and carrier gases required for payload operations. The payload-unique check gases shall be supplied using CIR-provided 75 ml bottle assemblies. Carrier gases shall be supplied using the standard CIR-provided 300 ml bottle assemblies.

3.3.2.1 Check Gas Mixture Requirements

The payload-unique check gas mixtures shall be limited to a maximum charged pressure of 12.4 MPa (1,800 psia) at 45°C and a maximum of 21% oxygen.

3.3.2.2 Carrier Gas Requirements

The payload-unique carrier gases (i.e., argon, helium, nitrogen, etc.) shall be limited to a maximum charged pressure of 12.4 MPa (1,800 psia) at 45°C.

3.3.3 CIR Adsorber Cartridge

The PD shall determine the type and mass of the adsorption media, to be inserted into the CIR Adsorber Cartridge, for each experiment. The CIR Adsorber Cartridge media will be documented in the payload-unique Data Set. The physical size of the CIR Adsorber Cartridge is provided in TABLE 12 . Examples of various media types available for packing into the cartridge are provided in TABLE 13 .

TABLE 12 PHYSICAL SIZE OF THE ADSORPTION CARTRIDGE BED

Internal Diameter mm (in)	Internal Length mm (in)	Internal Volume cc (in^3)	Empty Weight kg (lb)
76.2 (3)	307 (12.1)	1400 (85.4)	4.9 (10.8)

TABLE 13 ADSORBER MEDIA TYPES AVAILABLE

Adsorbent Media	Density g/cm^3 (lb/in^3)	Characteristics
Lithium Hydroxide	0.445 (0.016)	Removes acid gases
Activated Carbon	0.47 (0.017)	Removes hydrocarbons
Silica Gel	0.705 (0.026)	Removes water, alcohols, Olefins and aromatics
Molecular Sieve 13X	0.705 (0.026)	Removes water, alcohols and hydrocarbons

3.3.4 Vent Manifold O_2 Sensor Port

The PD has access to one O_2 sensor port on the Vent Manifold located on the back of the Optics Bench near the PIL. The location of this port is shown in FIGURE 37. The payload-provided O_2 sensor shall interface with this port through an SAE AS5202-02 Port or Fitting End, Internal Straight Thread, Design Standard.

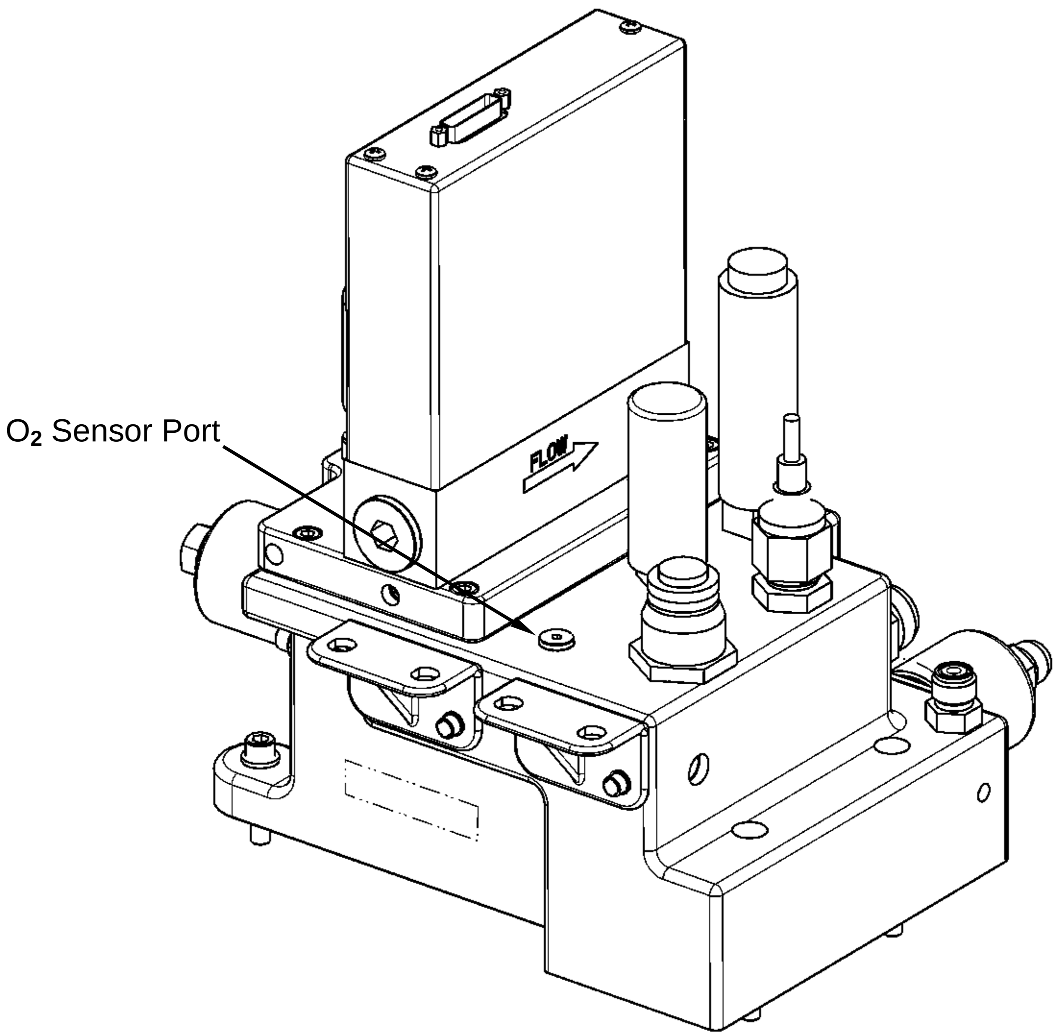


FIGURE 37 VENT MANIFOLD O_2 SENSOR PORT LOCATION

3.4 CIR-Provided Diagnostics

3.4.1 FCF Diagnostic Control Module

The FCF DCM provides servo and stepper motor control, power, ducted air-cooling, and mechanical alignment to CIR and payload-provided diagnostics packages. The FCF DCM provides a mechanical kinematic mount, electrical connector and air-cooling port as shown in FIGURE 38. Payload components may access the FCF DCM control and power interfaces without mechanically attaching to the FCF DCM via payload-provided electrical cables.

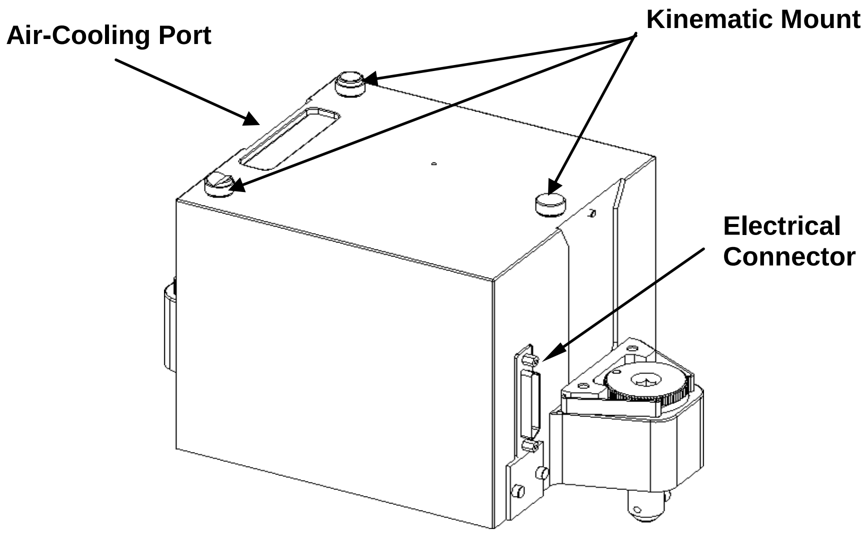
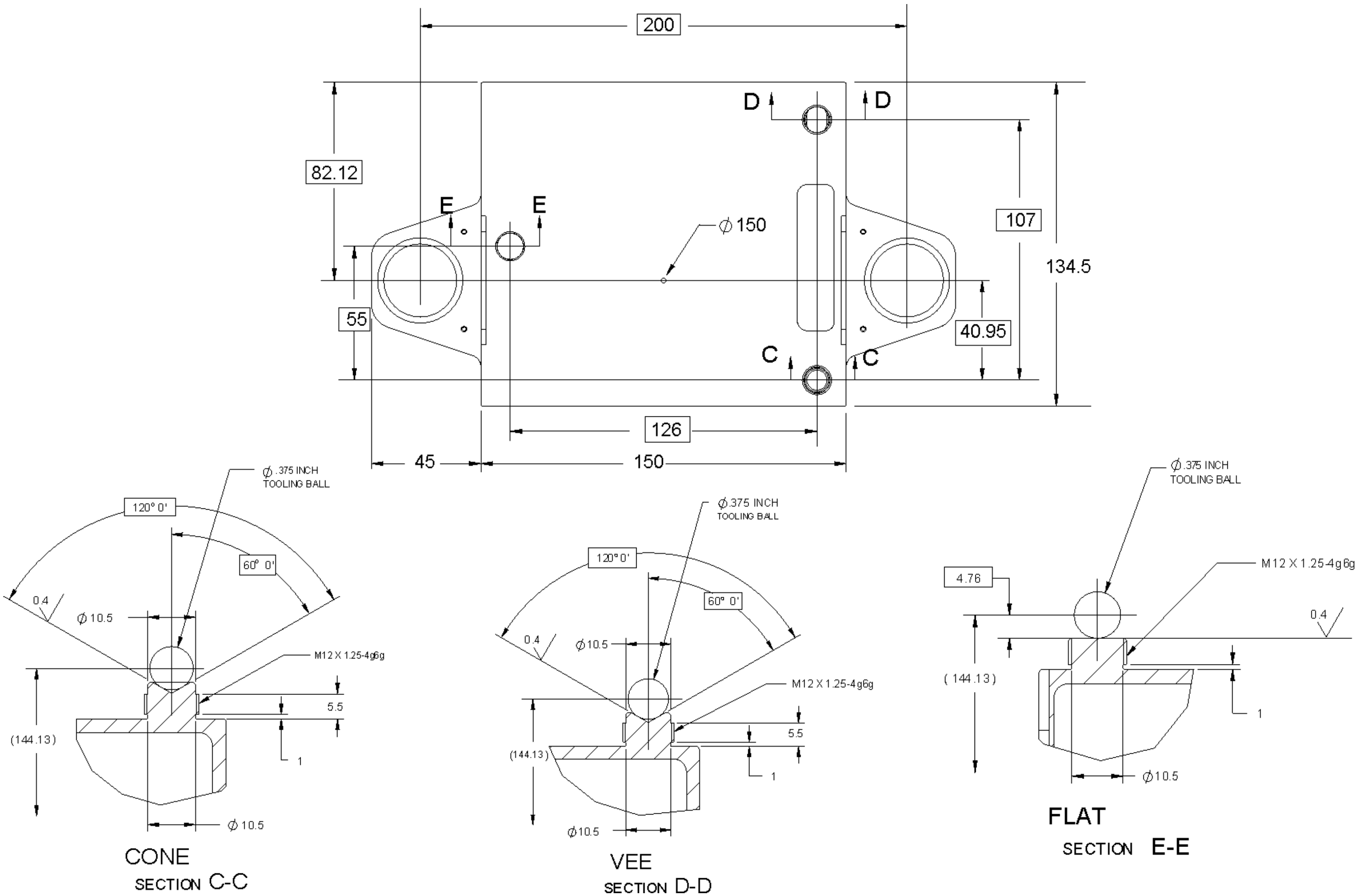


FIGURE 38 FCF DIAGNOSTIC CONTROL MODULE

3.4.1.1 FCF Diagnostic Control Module Kinematic Mount

Payload components mounting to an FCF DCM shall attach to the FCF DCM utilizing the Kinematic Mount. The dimensions of the Kinematic Mount, which are integral to the FCF DCM, are shown in FIGURE 39.

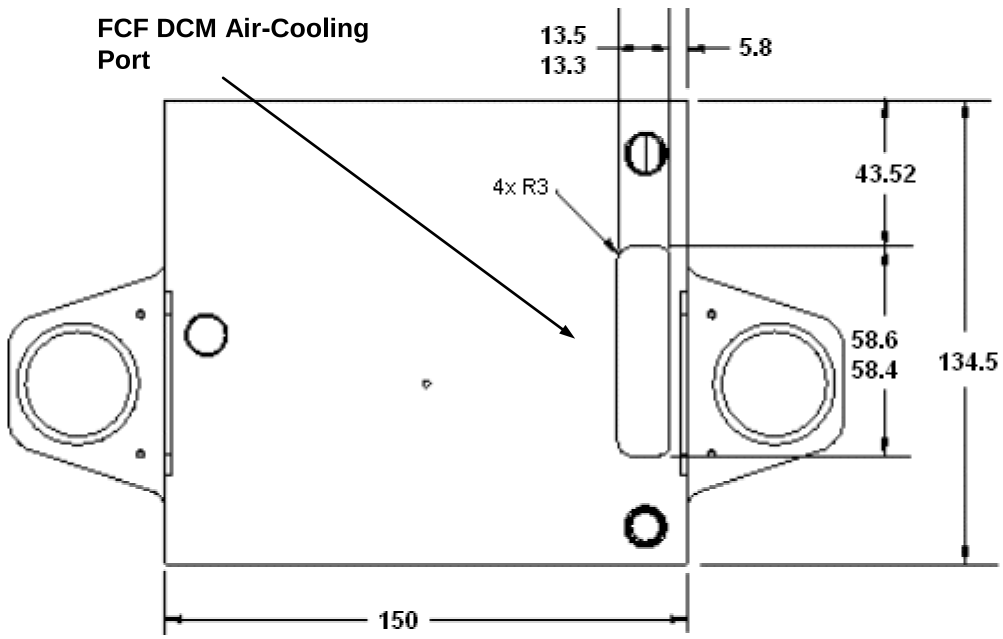


Note: All dimensions in millimeters unless otherwise noted.

FIGURE 39 FCF DCM KINEMATIC MOUNT

3.4.1.2 FCF Diagnostic Control Module Air-Cooling Port

Payload components that require FCF DCM air-cooling shall be compatible with the air-cooling port interface shown in FIGURE 40. Payload components interfacing to the FCF DCM Air-Cooling Port shall use a cushioning material to contact the FCF DCM surface. Payload components using a FCF DCM without additional hardware mounted to the Air-Cooling Port shall cover the air-cooling port to ensure proper air-cooling of the FCF DCM components.



Note: All dimensions in millimeters

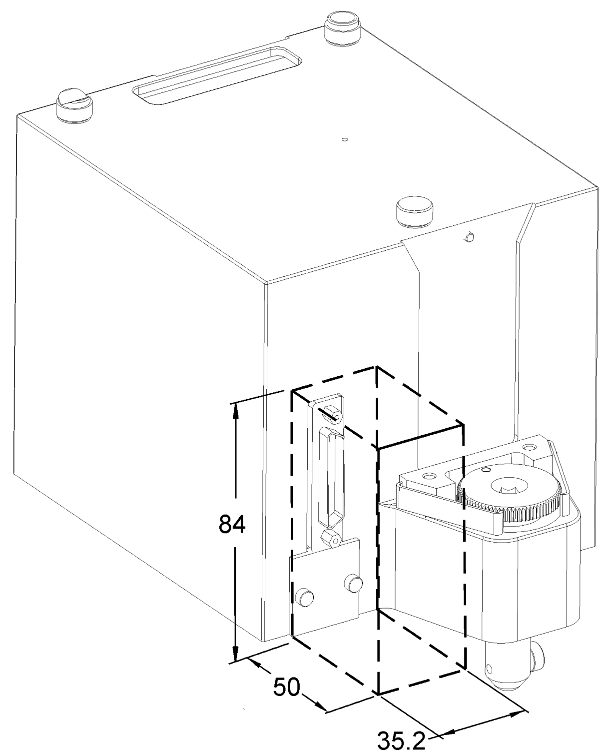
FIGURE 40 FCF DCM AIR-COOLING PORT

3.4.1.3 FCF Diagnostic Control Module Electrical Connector

The motor and sensor interface, camera control and power are provided through a 100 pin MIL-C-83513 connector, Airborne part number MK-432-100-125-6200. The payload-provided connector shall be Airborne part number MM-422-100-261-00WD-FP7. The location of the electrical connector on the FCF DCM is shown in FIGURE 41.

3.4.1.4 FCF Diagnostic Control Module Electrical Connector Envelope

Payload components mounted to the FCF DCM shall be compatible with the FCF DCM electrical connector envelope dimensions shown in FIGURE 41.



Note: All dimensions in millimeters

FIGURE 41 FCF DCM ELECTRICAL CONNECTOR ENVELOPE

3.4.2 CIR High Bit Depth/Multispectral Imaging Package

N/A

3.4.3 CIR High Frame Rate/High Resolution Imaging Package

N/A

3.4.4 CIR Low Light Level Ultraviolet Imaging Package

N/A

3.4.5 CIR Low Light Level Infrared Imaging Package

N/A

3.4.6 CIR Optics Housing Module

The CIR Optics Housing Module provides the air-cooling and electrical interfaces between the FCF DCM and the payload components. The CIR Optics Housing Module is shown in FIGURE 42. The CIR Optics Housing Module utilizes the Kinematic Mount to interface with the FCF DCM. The PD shall use the three-flange and/or the four-flange interface when attaching the payload components to the CIR Optics Housing Module.

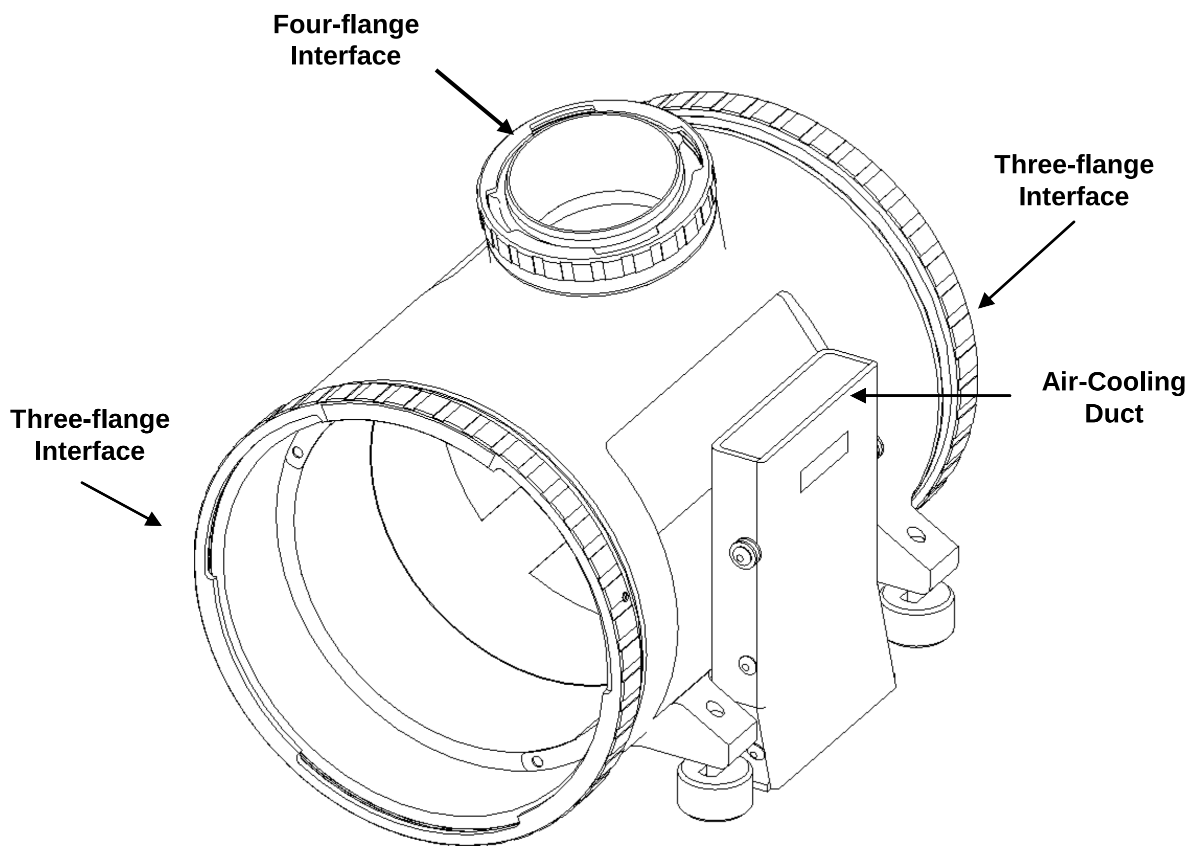
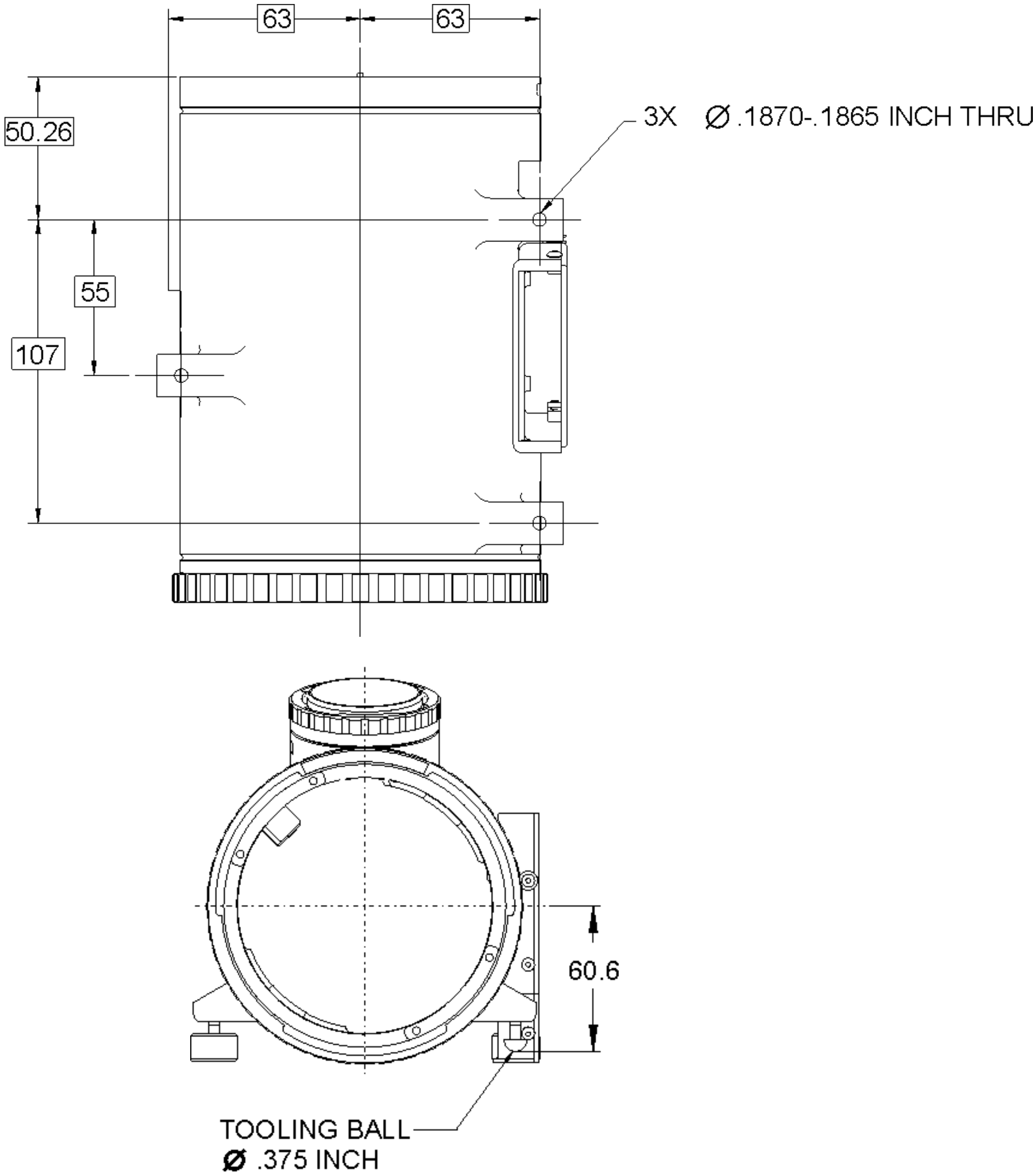


FIGURE 42 CIR OPTICS HOUSING MODULE

3.4.6.1 <u>CIR Optics Housing Module Kinematic Mount</u>

The CIR Optics Housing Module mounts to the FCF DCM using the Kinematic Mount. Details of the Kinematic Mount are shown in FIGURE 43. Payload components that utilize the CIR Optics Housing Module shall be compatible with the Kinematic Mount.

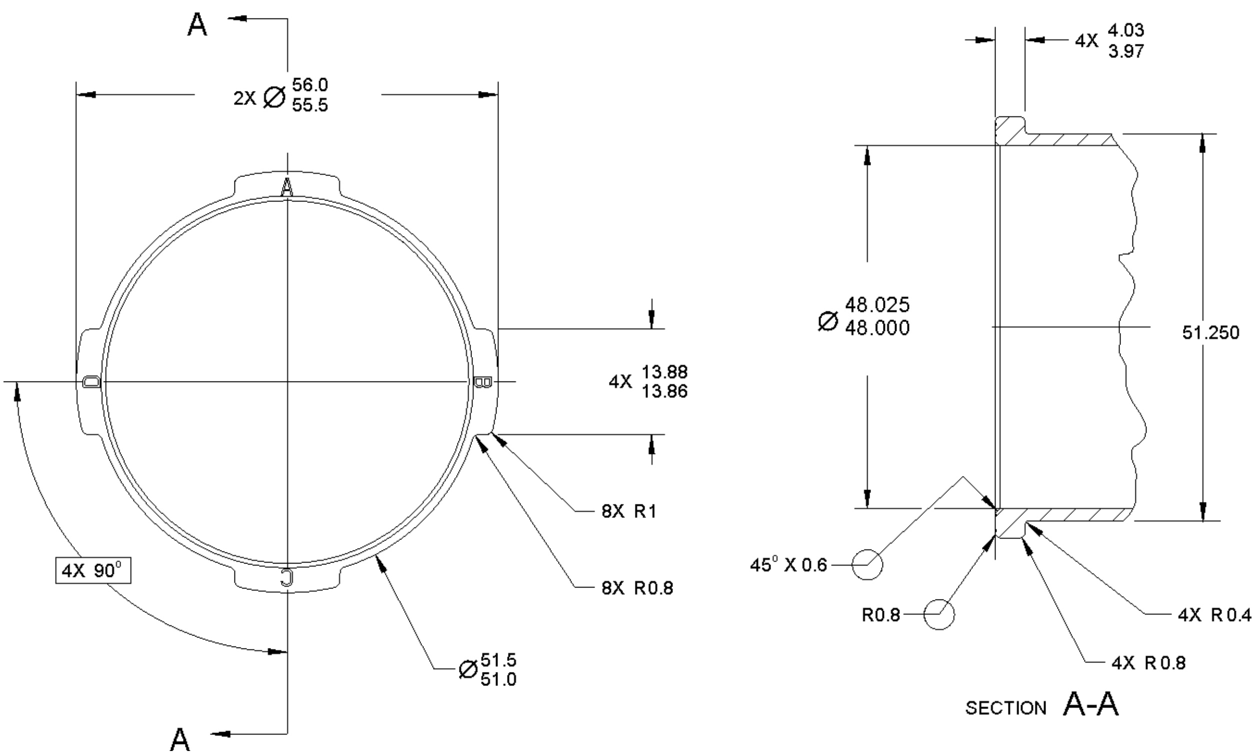


Note: All dimensions in millimeters unless otherwise noted

FIGURE 43 CIR OPTICS HOUSING MODULE - KINEMATIC INTERFACE

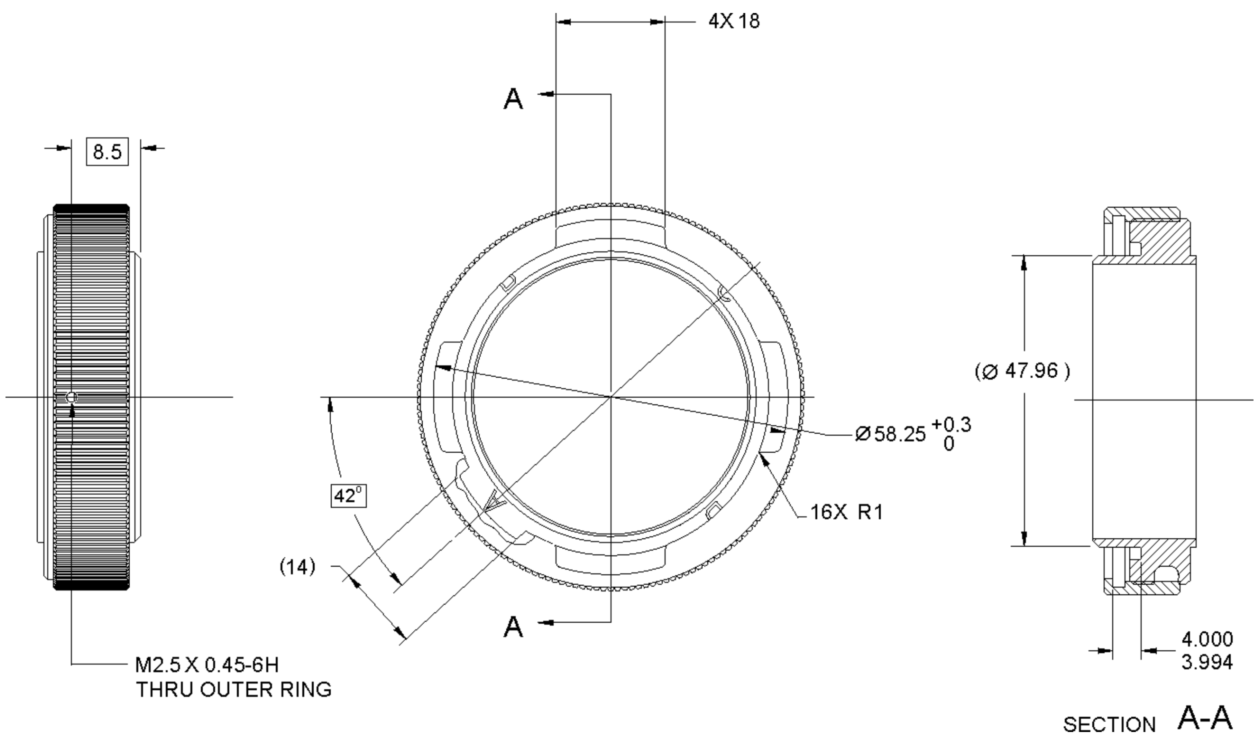
3.4.6.2 Four-Flange Interface

The payload Relay Optics Modules, Image Acquisition Modules, Prism Modules, Illumination Module, and the Iris Module that interface to the CIR Optics Housing Module shall utilize the four-flange interface. The four-flange interface is not keyed but the flanges are labeled as shown in FIGURE 44. The CIR Optics Housing Module Locking Ring details are shown in FIGURE 45.



Note: All dimensions in millimeters

FIGURE 44 FOUR-FLANGE INTERFACE DETAILS



Note: All dimensions in millimeters

FIGURE 45 LOCKING RING DETAIL

3.4.6.3 Three-Flange Interface

The payload Objective Optics Modules, and Mirror Modules that interface to the CIR Optics Housing Module shall utilize the three-flange interface shown in FIGURE 46.

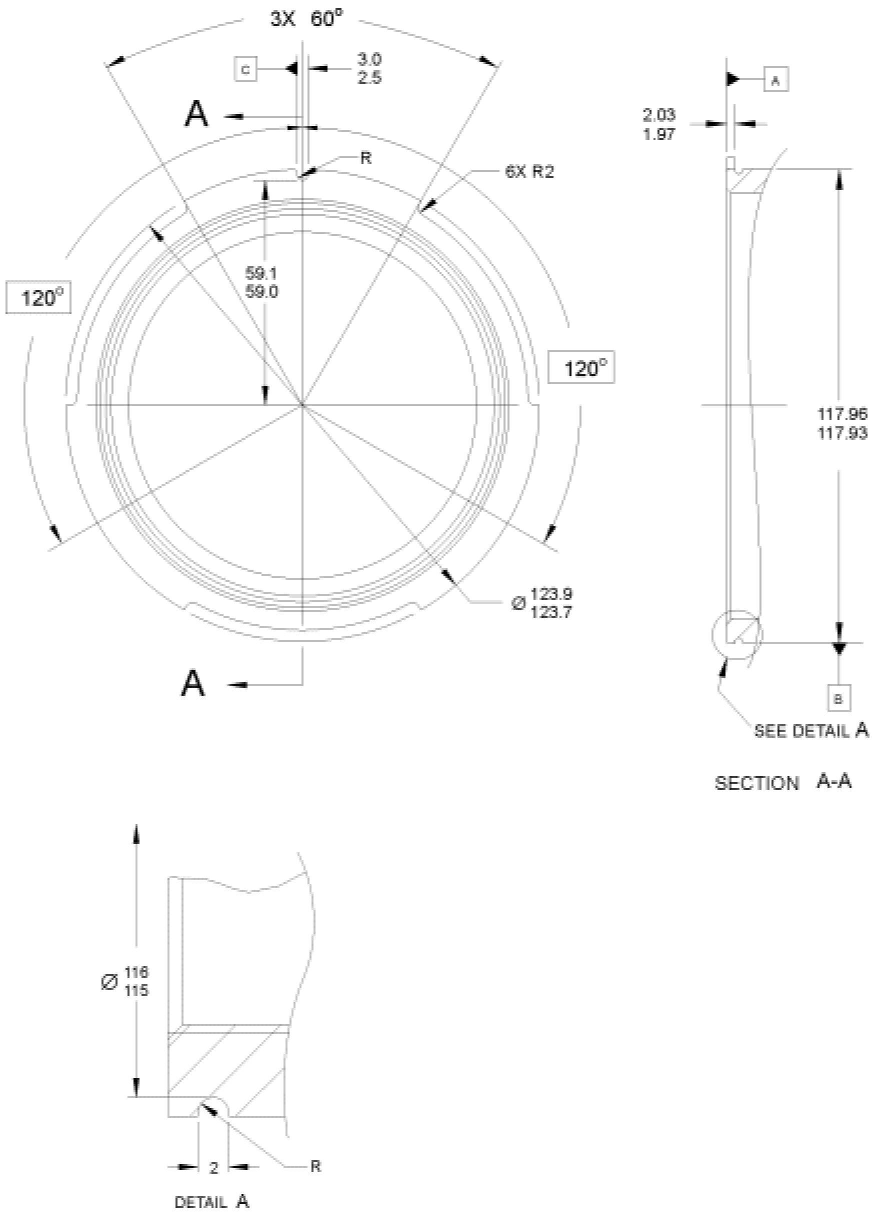


FIGURE 46 THREE-FLANGE INTERFACE DETAILS

3.4.6.4 CIR Optics Housing Module Electrical Connector

Payload components shall interface to the CIR Optics Housing Module using connector Airborne part number MK-242-021-225-2200 as shown in FIGURE 47.

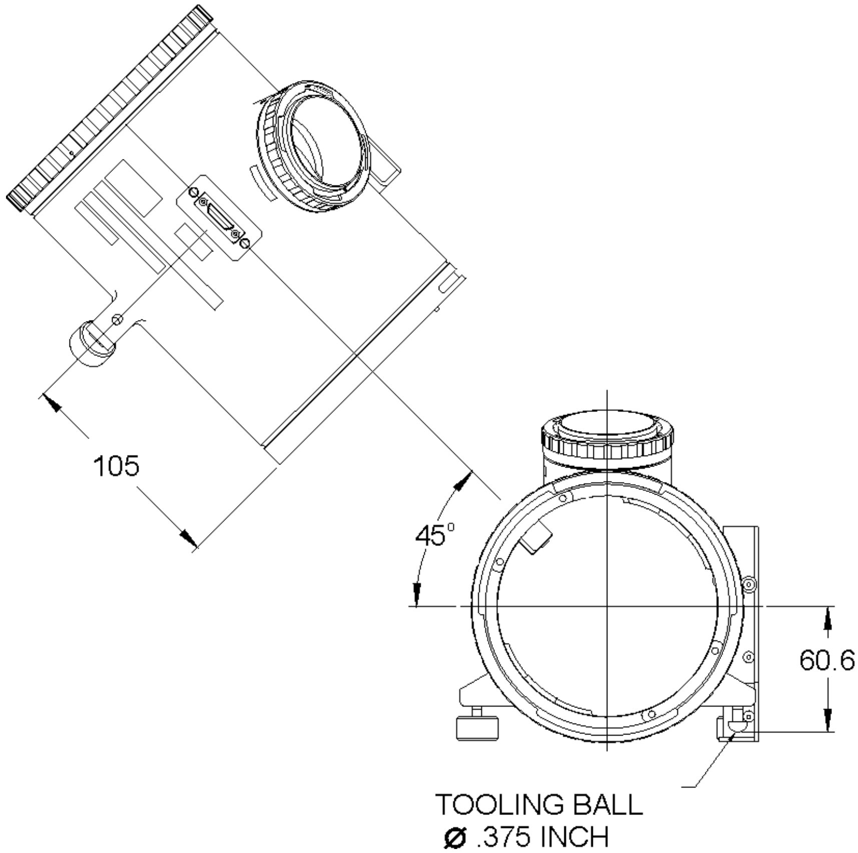


FIGURE 47 CIR OPTICS HOUSING MODULE ELECTRICAL CONNECTOR LOCATION

3.4.6.5 CIR Optics Housing Module Air-Cooling Duct

Payload components shall interface to the CIR Optics Housing Module air-cooling duct as shown in FIGURE 48. Payload components using the CIR Optics Housing Module without additional hardware mounted to the air-cooling duct shall cover the air-cooling duct to ensure proper air-cooling of the CIR Optics Housing Module components.

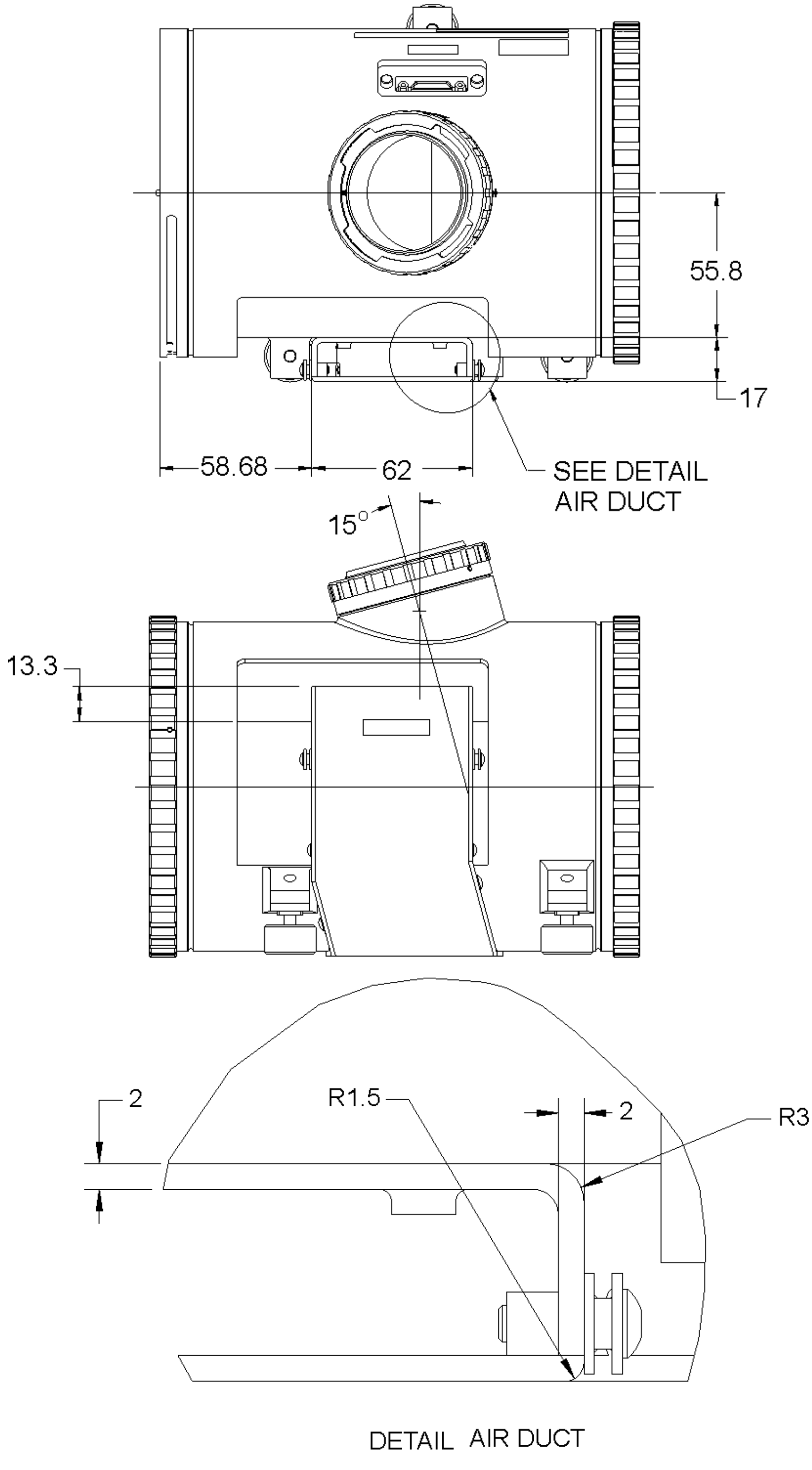


FIGURE 48 CIR OPTICS HOUSING MODULE AIR-COOLING DUCT

3.4.7 CIR Illumination Control Module

N/A

3.4.8 FCF Image Processing and Storage Unit

3.4.8.1 FCF Image Processing and Storage Unit Fiber Optic Connector

Payload components shall interface to the FCF Image Processing and Storage Unit (FCF IPSU) using the connector found on the front of the FCF IPSU as shown in FIGURE 49. The payload shall interface to the FCF IPSU Fiber Optic connector using the ST Fiber Optic Connector.

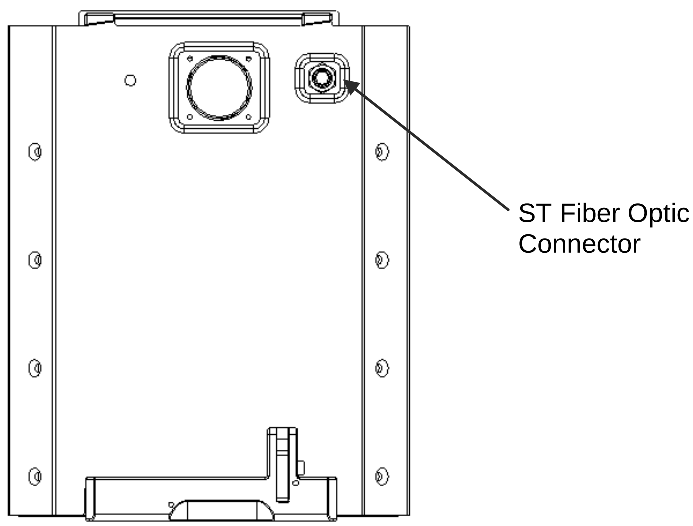


FIGURE 49 FCF IPSU FIBER OPTIC CONNECTOR

3.4.8.2 FCF Image Processing and Storage Unit Fiber Optic Connector Cable

Payload components that interface to the FCF IPSU Fiber Optic Connector Cable shall be compatible with the ST Fiber Optic Connector on the cable end.

3.4.9 FCF Image Processing and Storage Unit – Analog

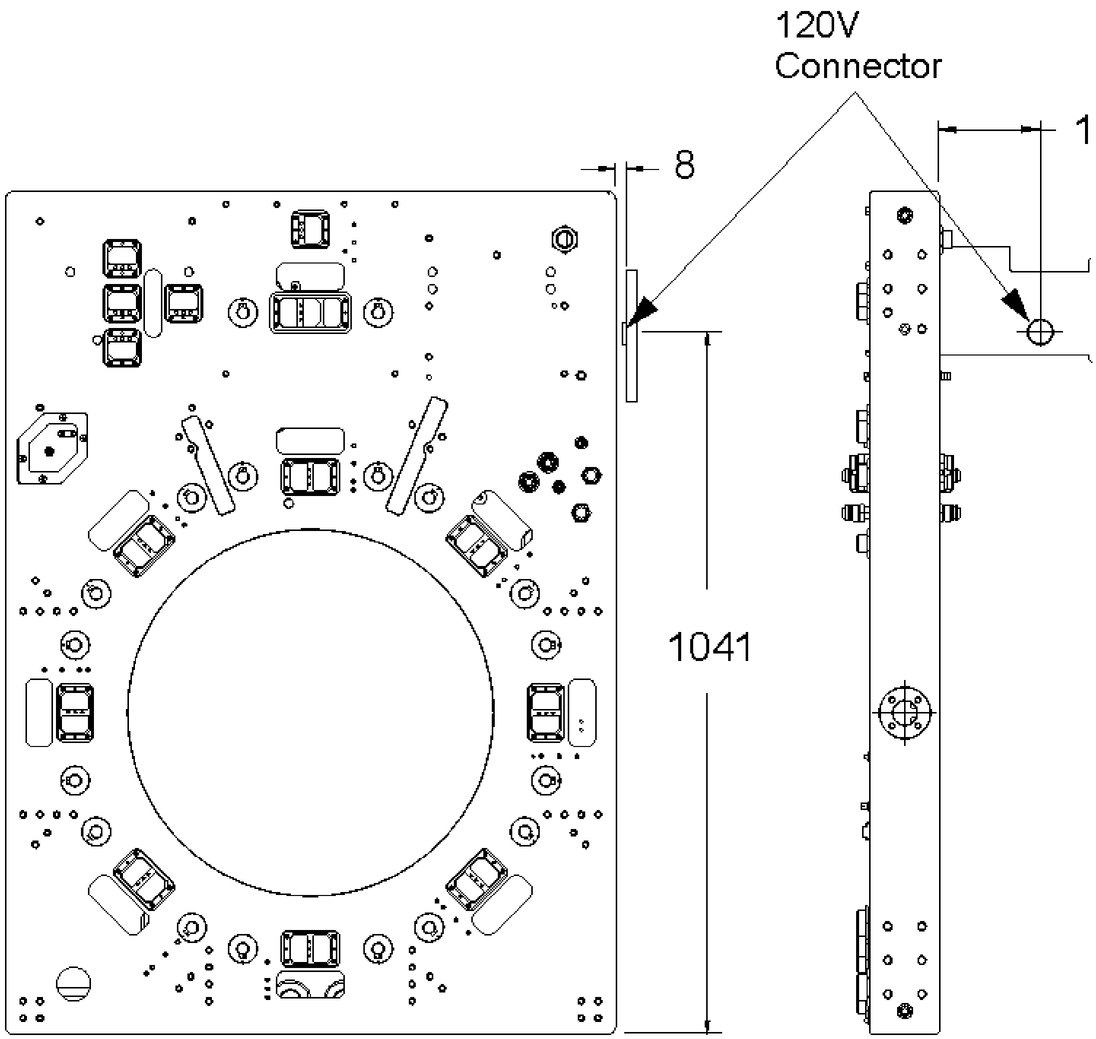
N/A

3.5 120 VDC Power Interface

3.5.1 120 VDC Power Interface Connector

A quantity of three 120 VDC, 4 Amp circuits from the Electrical Power Control Unit (EPCU) are routed to the left/rear side of the rack for use by the PD. Channels 1, 2, and 3 may be paralleled inside the PI Avionics Package or Combustion Chamber to increase the available power to a specific load.

Payload components may interface to the CIR-provided 120 VDC power connector, part number D38999/24FG16SN. The payload-provided mating connector shall be part number D38999/26FG16PN. The location of the 120 VDC connector is shown in FIGURE 50.

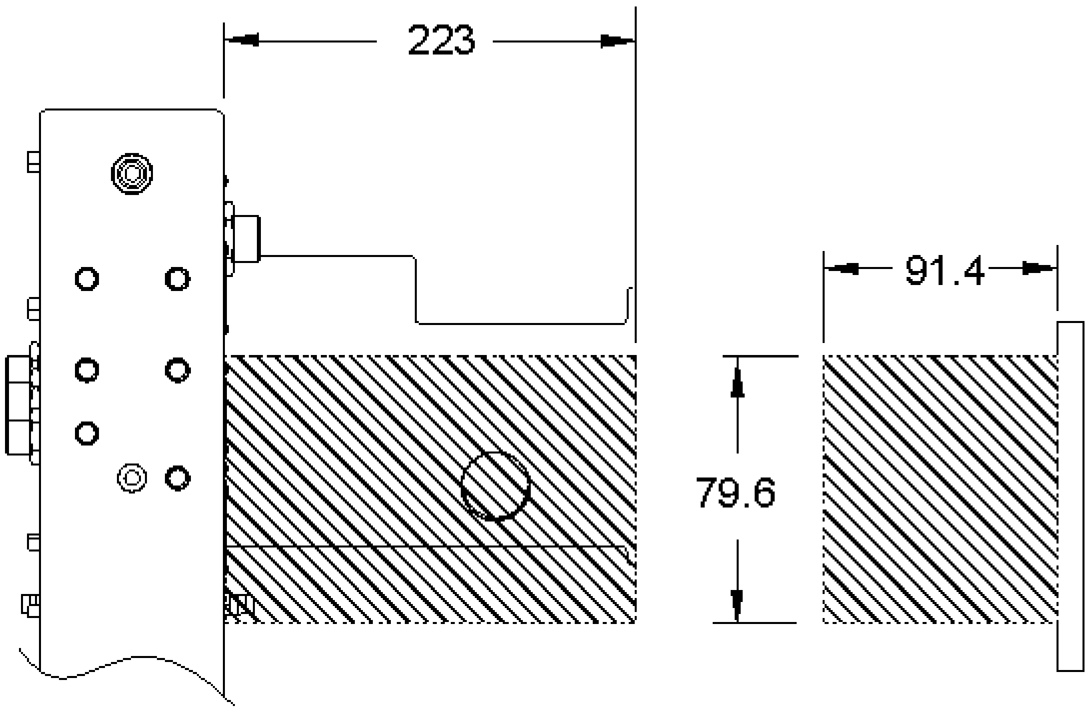


Notes:
1. View from the rear of the rack
2. All dimensions in millimeters

FIGURE 50 120 VDC POWER INTERFACE CONNECTOR

3.5.2 120 VDC Power Interface Connector Envelope

Payload components that utilize 120 VDC power interface shall be compatible with the connector envelope dimensions as shown in FIGURE 51 to allow for mating/demating operations.



Note: All dimensions in millimeters

FIGURE 51 120 VDC POWER INTERFACE CONNECTOR ENVELOPE

3.6 CIR/Payload Coordinate System

The location of the CIR within the U.S. Laboratory (USL) is LAB1S2, as shown in FIGURE 52.

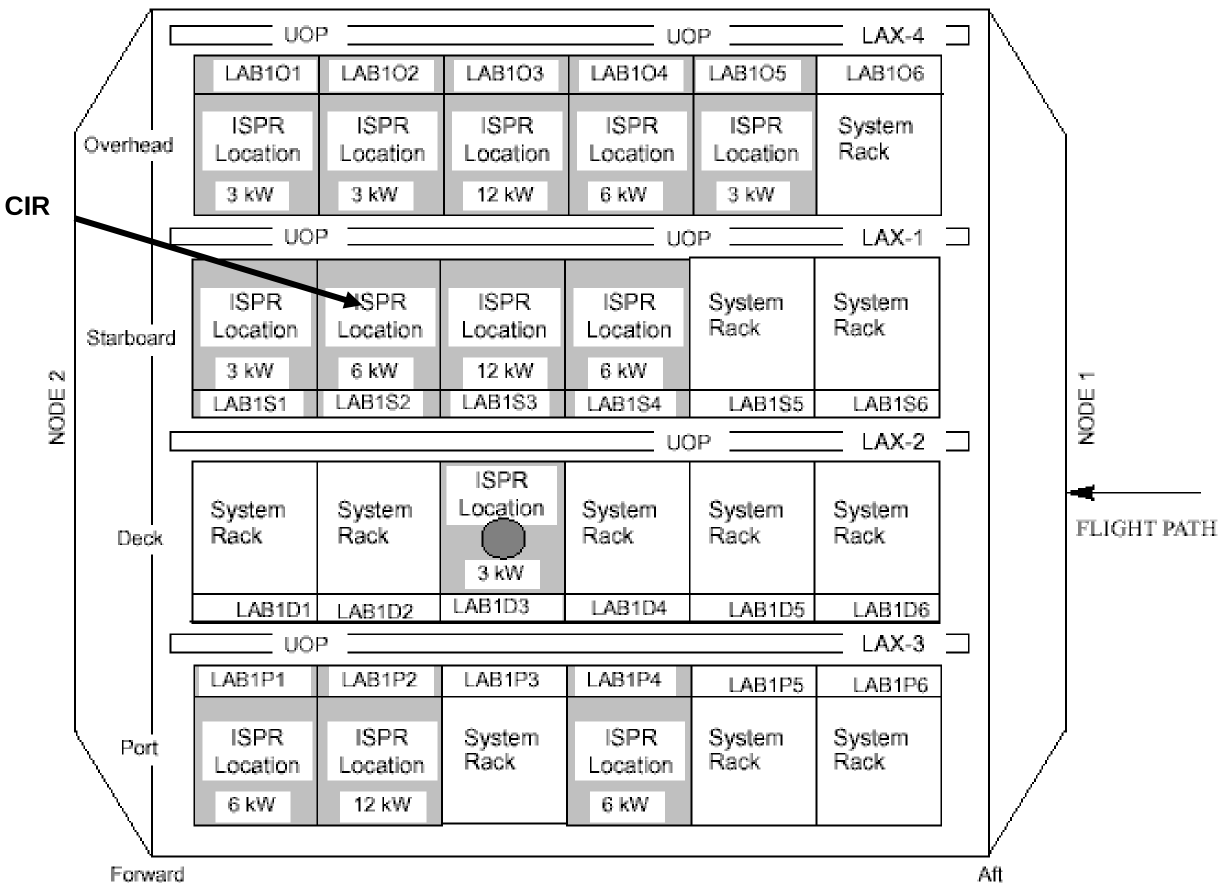


FIGURE 52 CIR LOCATION WITHIN THE U.S. LABORATORY

3.6.1 CIR Coordinate System

The rack coordinate system is shown in FIGURE 53.

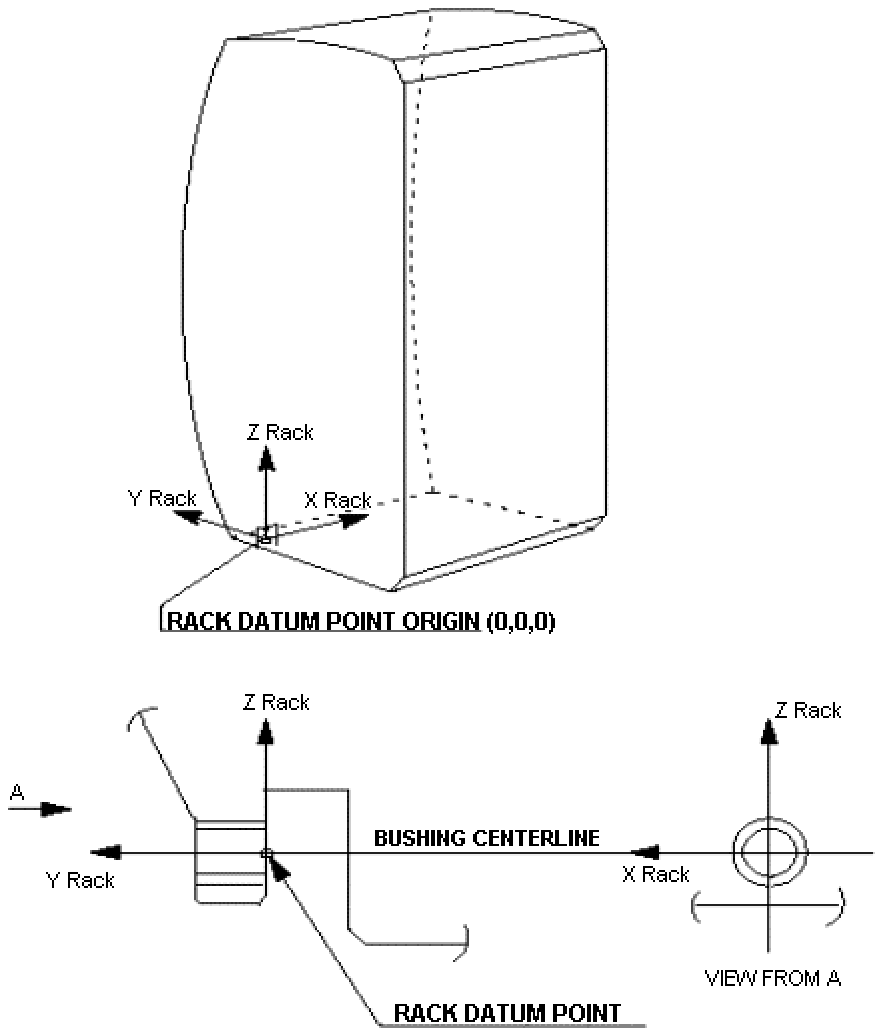


FIGURE 53 RACK COORDINATE SYSTEM

3.6.2 Optics Bench Coordinate System

The Optics Bench coordinate system is shown in FIGURE 54.

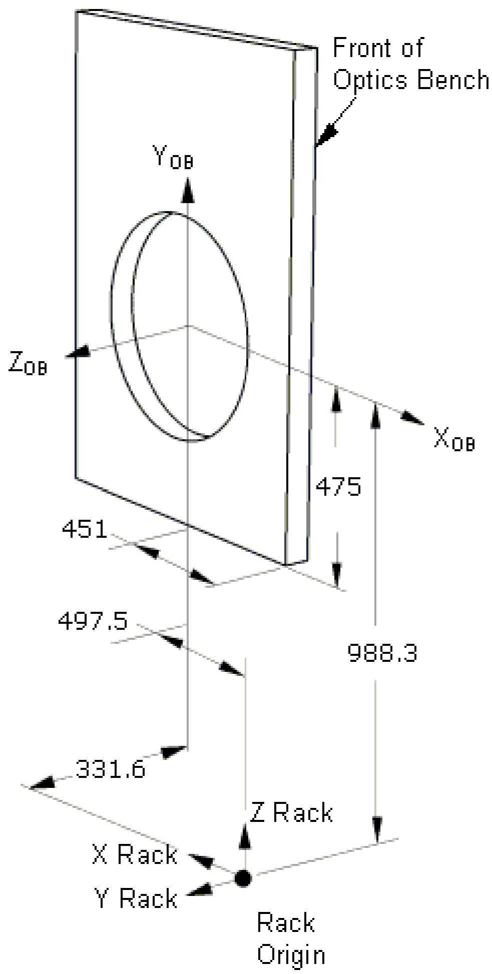


FIGURE 54 OPTICS BENCH COORDINATE SYSTEM

3.7 Dimensions and Tolerances

Unless otherwise specified, all linear and angular dimensions shall have tolerances as provided in TABLE 14 .

TABLE 14 TOLERANCES FOR LINEAR AND ANGULAR DIMENSIONS

Dimension Types	Range	Tolerance
Decimals (mm)	0 to 6 >6 to 30 >30 to 120 >120 to 315 >315 to 1000 >1000 to 2000	±0.1 ±0.2 ±0.3 ±0.5 ±0.8 ±1.2
Decimals (Inches)	X.X X.XX X.XXX	±0.03 ±0.01 ±0.005
Angles (Degrees)	0 to 360	±0° 30’

3.8 Mass and Center of Gravity

3.8.1 On-Orbit Center of Gravity Envelope

The PD shall show compliance with the CIR On-Orbit CG envelope for all payload configurations, referenced to the rack datum, as specified in TABLE 15 .

TABLE 15 INTEGRATED CIR ON-ORBIT CG ENVELOPE

Rack Configuration	CIR CG (mm) Referenced to the Rack Datum		
	X	Y	Z
On-Orbit Envelope	422 to 513	-355 to –283	969 to 1135

FIGURE 55 through FIGURE 61 are included to assist the PD with a methodology for determining the CG for each payload configuration. The following tables should be used in conjunction with FIGURE 55 through FIGURE 61.

The PD must determine the CIR configurable hardware and the payload components that will be used for each payload configuration. The following steps describe this process:

1. Determine the CIR hardware to be used for each payload configuration. The CIR configurable hardware available for use is provided in TABLE 16 .
2. Determine the hardware installation location on the Optics Bench. The coordinates for the interface locations are provided in TABLE 17 .
3. Translate the equipment CGs into the Optics Bench Coordinate System.
4. Determine the CG for the Optics Bench with all the payload components and CIR configurable hardware. The Optics Bench CG without CIR configurable hardware is provided in TABLE 18 .
5. Translate the Optics Bench CG into the rack coordinate system. The translation to the rack coordinate system is provided in TABLE 19 .
6. Combine the Optics bench CG with the rack CG, provided in TABLE 20 , to determine the total rack CG.

3.8.2 Mass Allocation

The mass required for all payload components and the CIR configurable hardware, for each payload configuration shall not exceed 216 kg. The CIR configurable hardware available for PD use is provided in TABLE 16 .

TABLE 16 CIR CONFIGURABLE HARDWARE AVAILABLE FOR PD USE

Equipment Name	Mass (Kg)	Center of Gravity (mm)			Origin (See Figure)
		X_{CG}	Y_{CG}	Z_{CG}	
CIR Adsorber Cartridge	4.9	-275.3	0.0	-26.9	FIGURE 59
CIR GC Argon Bottle	1.4	18.8	175.8	-9.4	FIGURE 60
CIR GC Check Gas Bottle	0.9	6.4	111.5	-18.5	FIGURE 60
CIR GC Helium Bottle	1.4	18.8	175.8	-9.4	FIGURE 60
CIR HFR/HR Imaging Package	9.3	-58.0	36.0	220.0	FIGURE 55
CIR HFR/HR Imaging Package (1)	9.3	**<TBD 03-02>**	**<TBD 03-02>**	**<TBD 03-02>**	FIGURE 55
CIR HiBMS Imaging Package	10.7	-88.1	17.4	207.0	FIGURE 55
CIR HiBMS Imaging Package (1)	9.8	**<TBD 03-03>**	**<TBD 03-03>**	**<TBD 03-03>**	FIGURE 55
CIR ICM	9.6	-100.0	36.0	220.0	FIGURE 56
CIR LLL-IR Imaging Package	10.6	-58.0	36.0	220.0	FIGURE 55
CIR LLL-UV Imaging Package	12.8	-58.0	36.0	220.0	FIGURE 55
CIR Manifold #x Bottle 3.80L	9.5	-317.3	17.3	-43.1	FIGURE 58
CIR Manifold #x Bottle 2.25L	6.6	-198.6	3.3	-45.9	FIGURE 58
CIR Manifold #x Bottle 1.00L	3.7	-80.6	9.4	-46.2	FIGURE 58
FCF IPSU and CIR IPSU Adapter	12.7	-91.2	9.5	133.9	FIGURE 57
FCF IPSU-Analog and CIR IPSU Adapter	12.2	-87.9	-2.2	141.3	FIGURE 57
FCF IPSU (Stacked) and CIR IPSU Adapter	21.8	-97.0	9.0	252.6	FIGURE 57
FCF IPSU-Analog (Stacked) and CIR IPSU Adapter	20.8	-93.5	-4.8	258.3	FIGURE 57
FCF IPSU (bottom), FCF IPSU-Analog (top) and CIR IPSU Adapter	21.3	-95.3	2.3	251.2	FIGURE 57
FCF IPSU-Analog (bottom), FCF IPSU (top) and CIR IPSU Adapter	21.3	-95.3	2.3	258.5	FIGURE 57
FCF UML Latch Handle	2.4	-89.4	46.23	169.7	FIGURE 61

Note: (1) IAM rotated 180 degrees due to hardware interference.

TABLE 17 HARDWARE INTERFACE LOCATIONS ON THE OPTICS BENCH

Location	Optics Bench Coordinates (mm)			Connector Reference Angle (degs)
	X	Y	Z	
Adsorber Cartridge Connection	276.0	332.0	-245.3	N/A
Chamber Insert (PD provided)	0.0	0.0	200.0	45.0
CIR GC Argon Bottle	353.5	-325.1	-238.2	N/A
CIR GC Check Gas Bottle	290.6	-440.0	-238.2	N/A
CIR GC Helium Bottle	413.0	-381.1	-238.2	N/A
CIR Manifold #1 (Diluent/Premixed Gas Supply Manifold)	350.0	575.0	-251.7	N/A
CIR Manifold #2 (High Percentage Oxygen Supply Manifold)	350.0	700.0	-251.7	N/A
CIR Manifold #3 (Nitrogen/High Pressure Supply Manifold)	350.0	450.0	-251.7	N/A
CIR Manifold #4 (Fuel/Premixed Fuel Supply Manifold)	-350.0	700.0	-251.7	N/A
PIL	100.0	590.1	0.0	180.0
UML 1	100.0	348.0	0.0	180.0
UML 2	-175.0	316.8	0.0	225.0
UML 3	-348.0	100.0	0.0	270.0
UML 4	-316.8	-175.4	0.0	315.0
UML 5	-100.0	-348.0	0.0	0.0
UML 6	175.0	-317.0	0.0	45.0
UML 7	348.0	-100.0	0.0	90.0
UML 8	316.8	175.4	0.0	135.0

TABLE 18 OPTICS BENCH CG WITHOUT CIR CONFIGURABLE HARDWARE

Package	Mass (Kg)	Center of Gravity (mm)		
		X_{OBCG}	Y_{OBCG}	Z_{OBCG}
Optics Bench	394.3	12.4	153.5	-23.5

Note: OBCG stands for Optics Bench Center of Gravity

TABLE 19 OPTICS BENCH TO RACK COORDINATE SYSTEM TRANSLATION

Rack Coordinate System	Translation (mm)
$X_{Rack\ CG}$	$497.5 - X_{OBCG}$
$Y_{Rack\ CG}$	$-331.6 + Z_{OBCG}$
$Z_{Rack\ CG}$	$988.3 + Y_{OBCG}$

TABLE 20 CIR CG IN THE RACK COORDINATE SYSTEM (WITHOUT THE OPTICS BENCH)

Package	Mass (Kg)	Center of Gravity (mm)		
		X_{RackCG}	Y_{RackCG}	Z_{RackCG}
CIR (without the Optics Bench)	423.3	424.1	-290.2	830.8

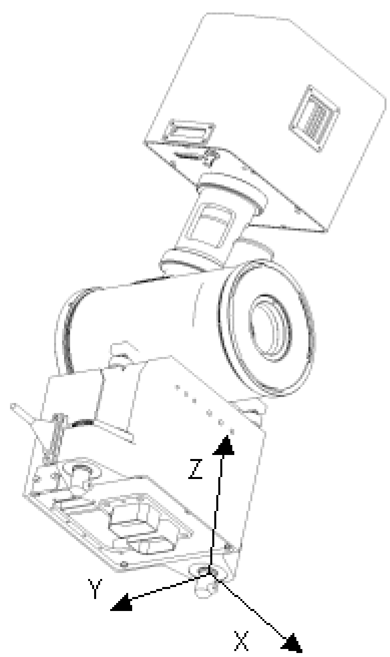


FIGURE 55 IMAGING PACKAGES LOCAL COORDINATE SYSTEM

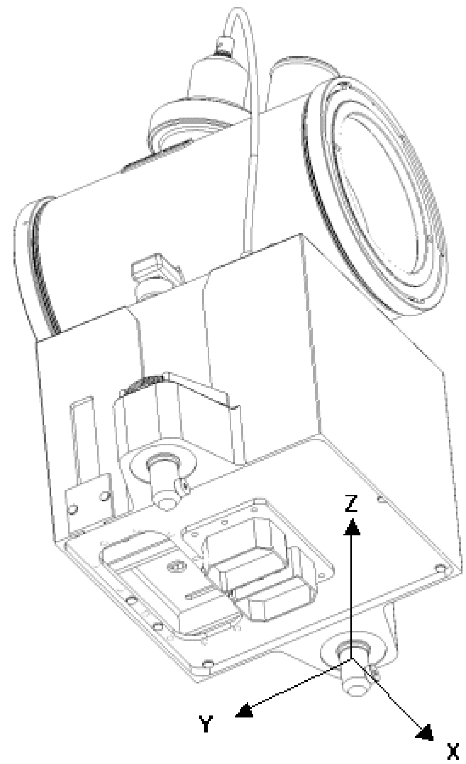


FIGURE 56 CIR ILLUMINATION PACKAGE LOCAL COORDINATE SYSTEM

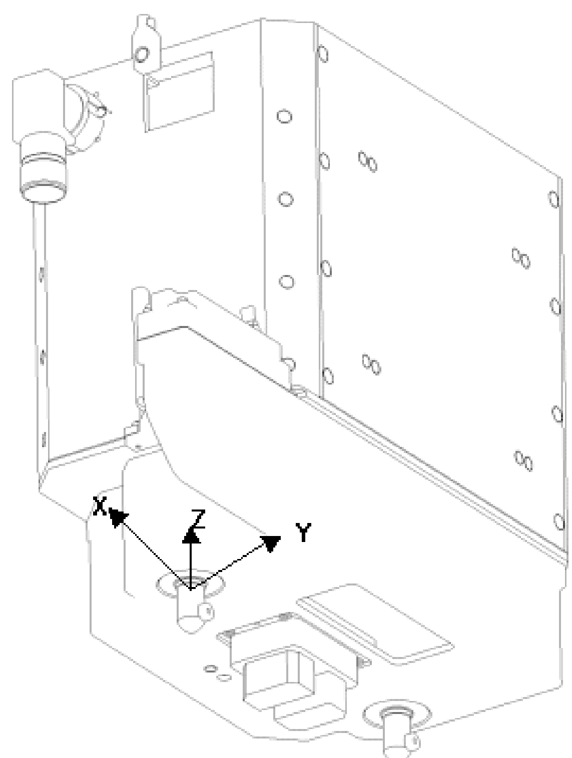


FIGURE 57 FCF IPSU/FCF IPSU-ANALOG LOCAL COORDINATE SYSTEM

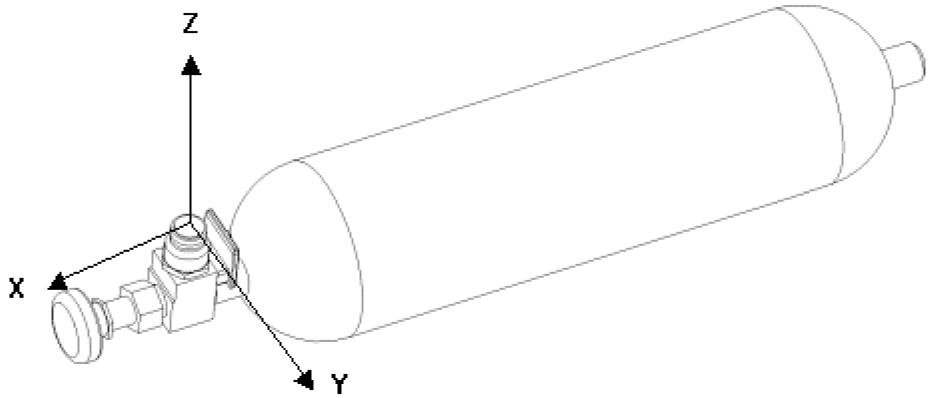


FIGURE 58 CIR MANIFOLD BOTTLE LOCAL COORDINATE SYSTEM

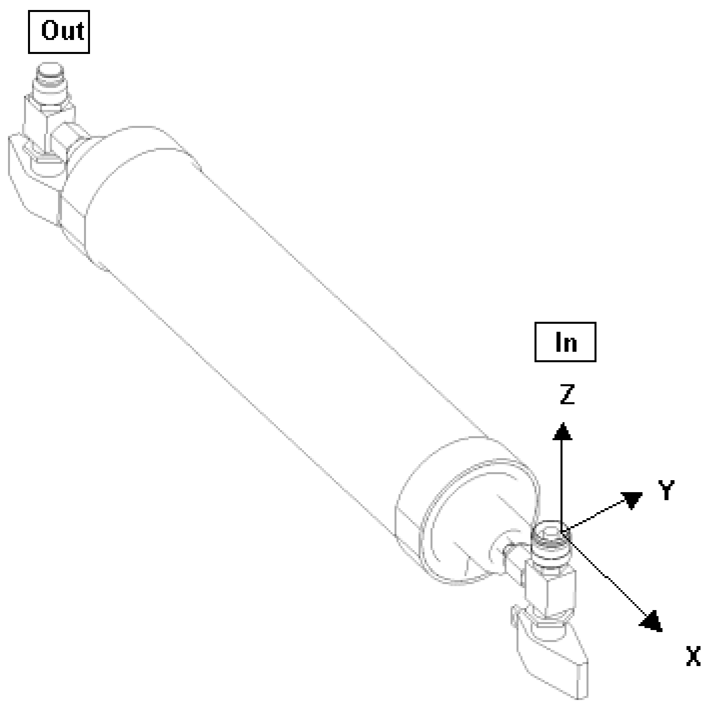


FIGURE 59 CIR ADSORBER CARTRIDGE LOCAL COORDINATE SYSTEM

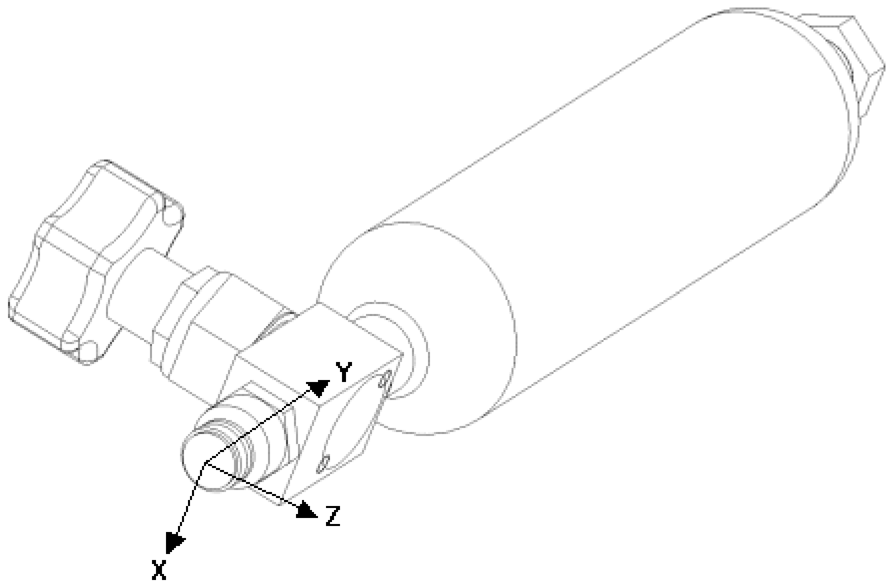


FIGURE 60 CIR GC ARGON/CIR CG HELIUM/CIR GC CHECK GAS BOTTLE LOCAL COORDINATE SYSTEM

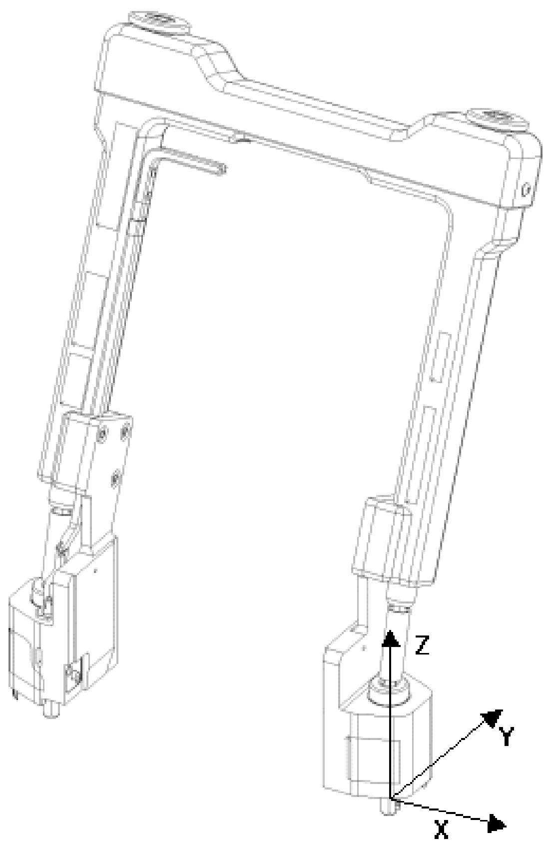


FIGURE 61 FCF UML LATCH HANDLE LOCAL COORDINATE SYSTEM

3.9 Stowage Provisions

The ISSP is responsible for assuring the design, development, definition, control, implementation, and accomplishment of pressurized stowage accommodations on the transportation vehicles used with the ISS and on-board the ISS. Typically, an FCF payload will be transported as MPLM "passive" cargo within soft stowage. This means that the payload does not require power or thermal conditioning during transportation to and from the ISS.

3.9.1 Multi-Purpose Logistics Module Interfaces

3.9.1.1 Multi-Purpose Logistics Module Late/Early Access Requirements

Payload components shall comply with SSP 57000, section 3.1.1.2.1, if late and/or early access from the MPLM is required.

3.9.2 Cargo Transfer Bags

Cargo Transfer Bags (CTBs) will be capable of providing stowage during MPLM transportation and on-orbit. The CTBs are available in half, single, double, and triple sizes as specified in TABLE 21 . Payload components shall be capable of fitting into these bags and shall not exceed the maximum load limit.

A CTB equivalent is 0.053 m^3 (1.86 ft^3) of cargo and packing material. Each configuration has a zipper closure and a removable mesh netting restraint system located inside of the CTB. Removable, reconfigurable dividers are used in conjunction with the CTBs to support all phases of cargo operations including launch, Intra-vehicular Activity (IVA) transfer, and repackaging for return to Earth. Each divider is composed of a non-flammable, Nomex enclosed, polyethylene foam with Velcro strips. Dividers are available in all of the sizes necessary to outfit a ½x, 1x, 2x, and 3x CTB.

TABLE 21 CARGO TRANSFER BAG SIZES

CTB	External Dimensions L x W x H cm (in)	Internal Dimensions L x W x H cm (in)	Maximum Load kg (lb)
Half (1/2x)	24.8 x 42.5 x 23.5 (9 .75 x 16.75 x 9.25)	23.2 x 41 x 21.9 (9.125" x 16.125 x 8.625)	13.62 (30)
Single (1x) with or without Windows	50.2 x 42.5 x 24.8 (19.75 x 16.75 x 9.75)	48.6 x 41 x 23.2 (19.125 x 16.125 x 9.125)	27.24 (60)
Double (2x)	50.2 x 42.5 x 50.2 (19.75 x 16.75 x 19.75)	48.6 x 41 x 46 (19.125 x 16.125 x 18.125)	54.48 (120)
Triple (3x)	74.9 x 42.5 x 50.2 (29.5 x 16.75 x 19.75)	73.34 x 41 x 46 (28.875" x 16.125 x 18.125)	81.72 (180)

3.9.3 Middeck Payload Transportation System

Payload components that are transported in the Orbiter Middeck (MDK) shall meet the MDK stowage requirements as defined in SSP 50467, section 4.1.3.

3.10 Ground Support Equipment

N/A

4.0 STRUCTURAL INTERFACES

4.1 Optics Bench

Structural load requirements specific to the payload components mounted to the rear of the Optics Bench are provided in subsequent sections. Fasteners or attachment hardware should satisfy the Optics Bench limitations. All safety critical fasteners shall be of size #8 or above and comply with the requirements of FCF-PLN-0029. Applied torque on all fasteners interfacing with the Optics Bench shall follow the specification in FCF-DOC-0118.

4.1.1 Universal Mounting Locations

4.1.1.1 Universal Mounting Location Threaded Mounting Holes

The torque supplied to secure the payload components to the UML threaded mounting holes using ¼ -28 UNF-3A fasteners shall not exceed 8.5 N-meter (75 in-lb_f). The external loads applied on each individual fastener hole due to crew-induced loads or any other loading condition shall not exceed 3.3 kN (750 lb_f) axial and 3.3 kN (750 lb_f) shear.

4.1.1.2 Universal Mounting Location Mounting Holes

Payload components mounting to the UML mounting holes shall not exert a normal force greater than 4.4kN (1000 lb_f) or a shear force greater than 4.4kN (1000 lb_f) at each UML mounting hole, as shown in FIGURE 3.

4.1.1.3 Universal Mounting Location Electrical Connector

N/A

4.1.1.4 Universal Mounting Location Air-Cooling Interface

N/A

4.1.1.5 FCF Universal Mounting Location Latch Handle Provisions

N/A

4.1.2 Principal Investigator Location

4.1.2.1 Principal Investigator Location Threaded Mounting Holes

The torque supplied to secure the payload components to the PIL threaded mounting holes using ¼ -20, A-286 stainless steel fasteners shall not exceed 8.5 N-meter (75 in-lb_f). The external loads applied on each individual fastener hole due to crew-induced loads or any other loading condition shall not exceed 3.3 kN (750 lb_f) axial and 3.3 kN

(750 lb_f) shear.

4.1.2.2 Principal Investigator Location Mounting Holes

Payload components mounting to the PIL mounting holes shall not exert a normal force greater than 4.4kN (1000 lb_f) or a shear force greater than 4.4kN (1000 lb_f) at each PIL mounting hole, as shown in FIGURE 11.

4.1.3 Auxiliary Interface Connectors

N/A

4.2 Combustion Chamber

Payload components within the Combustion Chamber shall maintain positive margins of safety when exposed to the Combustion Chamber lower pressure limit of 0.133 kPa (0.019 psia) to the MDP of 931 kPa (135 psia).

4.2.1 Interface Resource Ring

N/A

4.2.2 CIR Rear End-Cap Port Plug Interface

N/A

4.2.3 Rear Access Port

N/A

4.2.4 Window Ports

N/A

4.2.5 Mounting Rails

Payloads utilizing the Combustion Chamber mounting rails shall not exert shear and axial loads on the rail mounting fasteners exceeding the allowable load limit of 250 lbs each under any on-orbit loading condition. The maximum crew induced load is limited to 50 lbs on the payloads integrated into the Combustion Chamber.

4.2.6 Axial Locating Slots

N/A

4.2.7 Vacuum Exhaust System Interface

N/A

4.2.8 Vacuum Resource System Interface

N/A

4.3 Fuel/Oxidizer Management Assembly

N/A

4.4 CIR-Provided Diagnostics

4.4.1 FCF Diagnostic Control Module

4.4.1.1 FCF Diagnostic Control Module Kinematic Mount

Payload components attached to the Kinematic Mount shall not exert a normal force greater than 1.8 kN (400 lb_f) or a shear force greater than 1.8 kN (400 lb_f) on each Kinematic Mount boss, as shown in FIGURE 39.

4.4.1.2 FCF Diagnostic Control Module Air-Cooling Port

N/A

4.4.1.3 FCF Diagnostic Control Module Electrical Connector

N/A

4.4.2 CIR High Bit Depth/Multispectral Imaging Package

N/A

4.4.3 CIR High Frame Rate/High Resolution Imaging Package

N/A

4.4.4 CIR Low Light Level Ultraviolet Imaging Package

N/A

4.4.5 CIR Low Light Level Infrared Imaging Package

N/A

4.4.6 CIR Optics Housing Module

N/A

4.4.7 CIR Illumination Control Module

N/A

4.4.8 FCF Image Processing and Storage Unit

N/A

4.4.9 FCF Image Processing and Storage Unit – Analog

N/A

4.5 120 VDC Power Interface

N/A

4.6 Payload Launch and Landing Loads

Payload components shall be designed to maintain positive margins of safety during lift-off and landing events. For design purposes, the acceleration environment defined in SSP 57000, Table 3.1.1.3-4 shall be used.

4.7 Random Vibration

Payload components packed in foam and launched in a stowage container, shall be significantly isolated from the launch random vibration environment.

Electro-mechanical payload components shall survive workmanship level vibrations of 6.8 grms per NASA-STD-7001, Table 1.

Payload components whose individual masses are greater than or equal to 11.3 kg (25 lbs) shall be designed to have no natural frequency below 35 Hz under on-orbit mounting conditions. The Optics Bench including CIR configurable hardware, Combustion Chamber, and payload components mounted in their on-orbit configuration with free-free boundary conditions, shall have a resonant frequency greater than 25 Hz.

4.8 On-Orbit Loads

4.8.1 Crew Induced Loads

Payload components shall be designed to maintain positive margins of safety when exposed to the crew-induced loads defined SSP 57000, Table 3.1.1.3-1.

4.8.2 Other On-Orbit Loads

Payload components shall be designed to maintain positive margins of safety when exposed to on-orbit loads of 0.2 g’s acting in any direction.

4.9 Payload Structural Design

4.9.1 Structural Design

Payload components that include pressure vessels, glass, window, and ceramic structures, shall be designed in accordance with the requirements specified in NSTS 1700.7B, NSTS 1700.7B/ISS Addendum, NSTS 18798B, and SSP 52005. Positive margins of safety shall be maintained for all mission phases.

4.9.2 Fracture Control

Payload components, including all pressure vessels, the failure of which would cause damage to the orbiter, damage to the ISS, or injury to personnel, shall be analyzed to preclude failures caused by propagation of pre-existing flaws. The PD shall provide fracture control documentation of critical structural components in accordance with NSTS 1700.7B, NSTS 1700.7B/ISS Addendum, NSTS 13830, NSTS 18798B (including JSC Letter TA94-057), NASA-STD-5003, and SSP 52005B during the payload safety review process.

4.10 Acoustics

Payload components will satisfy the acoustic requirements as defined in the following sections.

4.10.1 Payload-Generated Acoustic Noise

The CIR, together with the payload components, cannot operate above NC–40 except in those cases where the noise level meets the Intermittent Noise Source requirements as specified in section 4.10.1.2.2 of this document.

4.10.1.1 Acoustic Noise Definitions

A Continuous Noise Source is a significant noise (>37 dBA) that exists for a cumulative total of 8 hours or more in a 24-hr period. An Intermittent Noise Source is a significant noise source that exists for a cumulative total of less than 8 hours in a 24-hr period.

4.10.1.2 Acoustic Noise Limits

The acoustic noise limits are identified in subsequent sections. These levels cannot be exceeded when the payload components are operating in the loudest expected configuration and mode of operation that can occur on-orbit during any planned operations. Acoustic noise limits are measured in front of the rack at 0.6 m (1.97 ft) distance from the noisiest surface with equipment operating in the mode or condition that produces the maximum acoustic noise.

Note: These acoustic requirements do not apply during failure or maintenance operations.

4.10.1.2.1 Continuous Noise Limits

Payload components that generate continuous noise levels shall not exceed the limits provided in TABLE 22 , for all octave bands in their loudest configuration. The levels specified in TABLE 22 are allocations for the payload measured in an acoustics laboratory not installed into the rack or in the Combustion Chamber. A distinction is made for the payload components mounted inside the Combustion Chamber and for payload components and CIR configurable hardware outside the Combustion Chamber. The acoustic limits will be higher for components in the Combustion Chamber than components located on the Optics Bench. These higher values are attainable because of the larger transmission loss factors of the Combustion Chamber.

TABLE 22 CONTINUOUS ACOUSTIC NOISE LIMITS AT MAXIMUM ATCU FAN SPEED OF 2200 RPM

Frequency Band (Hz)	Total Rack Based on NC-40 (dB)	Payload Within Combustion Chamber (dB)	Payload Outside Combustion Chamber (dB) (1)
63	64	57	54
125	56	51	48
250	50	60	49
500	45	60	50
1000	41	60	49
2000	39	58	46
4000	38	57	46
8000	37	56	46

Note: (1) Includes the CIR configurable hardware

4.10.1.2.2 Intermittent Noise Limits

The payload classified as an intermittent noise source shall comply with the limits specified in TABLE 23 . These levels pertain to the payload tested in an acoustics laboratory and not installed into the rack and/or Combustion Chamber.

TABLE 23 INTERMITTENT ACOUSTIC NOISE LIMITS

Time NC-40 is Exceeded During a 24-Hour Period [(1)]	Total Rack SPL [(2)] (dBA)	Payload Within Combustion Chamber SPL (dBA)	Payload Outside Combustion Chamber SPL [(3)] (dBA)
8 Hours	49	46	36
7 Hours	50	47	37
6 Hours	51	48	38
5 Hours	52	49	39
4.5 Hours	53	50	40
4 Hours	54	52	42
3.5 Hours	55	53	43
3 Hours	57	55	45
2.5 Hours	58	61	51
2 Hours	60	62	52
1.5 Hours	62	65	55
1 Hour	65	68	58
30 Minutes	69	72	62
15 Minutes	72	76	66
5 Minutes	76	80	70
2 Minutes	78	82	72
1 Minute	79	83	73
Not Allowed	80	84	74

Notes:

[(1)] If the noise from the payload were at the level in this table for the duration specified in this column, no other payload operation would be permitted during the remainder of the 24-hour period.

[(2)] Measured at 0.6 m (1.97 ft) distance from the noisiest surface with equipment operating in the mode or condition that produces the maximum acoustic noise. Round dBA to the nearest whole number.

[(3)] Includes the payload components and CIR configurable components.

The duration is the total time that the payload produces noise above the NC-40 limit during a 24-hour period. This duration is the governing factor in determining the allowable intermittent noise limits. Regardless of the number of separate sources and varying durations, this cumulative duration shall be used to determine the A-weighted Sound Pressure Level (SPL) limit.

For example, if a payload component outside the Combustion Chamber produces a noise level of 60 dBA for 30 minutes in a start-up mode and then settles down to 55 dBA for one additional hour of normal operation, it does not comply with the intermittent noise requirement since the A-weighted SPL exceeds 55 dBA during the 1.5 hour duration.

4.10.1.2.3 Continuous Noise Sources with Intermittent Noise Features

Continuous noise sources, which exhibit intermittent acoustical characteristics, shall meet both the continuous noise specifications and the intermittent limits of sections 4.10.1.2.1 and 4.10.1.2.2 of this document. The intermittent noise characteristics must be quantified in terms of:

A. When the intermittent sound occurs
B. Duration
C. Projected mission timeline(s)

For items (A) and (B), listed above, the maximum A-weighted SPL measured at a 0.6-meter (1.97 ft) distance from the loudest part of the equipment shall be determined.

4.10.1.3 Use of Vacuum Exhaust System

In addition to meeting the above acoustic requirements, the following information shall be required for the final acoustic verification report. The payload that uses the VES shall list all exhaust requirements in terms of volume, pressure (maximum and nominal), flow rate (maximum and duration), and time-to-exhaust-to-vacuum requirements. The vacuum event information shall include a description of the vacuum exhaust event timelines and whether they correspond to crew activities or are based upon self-activation or telescience activities.

4.10.2 CIR Payload Acoustic Environment

Payload components shall be compatible with the CIR acoustic environment specified in TABLE 24 . These levels are calculated based on measurements obtained from microphones inside the CIR during acoustic testing and do not include the noise generated by the payload.

TABLE 24 CIR PAYLOAD ACOUSTIC ENVIRONMENT AT A MAXIMUM ATCU FAN SPEED OF 2400 RPM

Frequency (Hz)	Within Combustion Chamber (dB)	Front of Optics Bench (1) (dB)	Behind Optics Bench (1) (dB)
63	70	74	69
125	72	77	74
250	48	75	73
500	47	74	74
1000	44	71	71
2000	36	63	72
4000	30	57	65
8000	20	47	58

Notes: (1) Outside Combustion Chamber.

4.11 Depressurization/Repressurization Requirements

Payload components containing trapped volumes must maintain positive margins of safety per NSTS 1700.7B, NSTS 1700.7B/ISS Addendum, NSTS 18798, and SSP 52005 when exposed to the worst-case depressurization/repressurization environments as defined in the following sections.

4.11.1 U.S. Laboratory Maximum Depressurization/Repressurization Rates

Payload components shall maintain positive margins of safety for the depressurization and repressurization rates specified for an on-orbit payload located in the USL. The maximum depressurization rate is 878 Pa/s (7.64 psi/min) and the maximum repressurization rate is 230 Pa/s (2 psi/min).

4.11.2 MPLM Maximum Depressurization/Repressurization Rates

Payload components shall maintain positive margins of safety for MPLM depressurization/repressurization rates as defined in SSP 57000, section 3.1.1.2 paragraph B.

4.11.3 Portable Fire Extinguisher Discharge Rate

Payload components shall maintain positive margins of safety when exposed to the Portable Fire Extinguisher (PFE) discharge rate specified in SSP 57000, Figure 3.1.1.4-1.

4.12 Ground Handling Environments

Payload components that have the potential to create a flight safety hazard if damaged during ground transportation (including fracture-critical parts or components), will be analyzed for applicable ground transportation and handling events in accordance with the following sections.

4.12.1 Ground Handling Load Factors

Payload components that have the potential to create a flight safety hazard if damaged during handling and transportation (including fracture-critical parts or components) shall be analyzed in accordance with SSP 52005 using the transportation limit load factors specified in TABLE 25 (for typical operations). These analyses shall evaluate the flight hardware in the shipping container configurations.

TABLE 25 LIMIT LOAD FACTORS (g)-GROUND HANDLING (ROAD/AIR/BARGE) OPERATIONS

Transportation Environment	Limit Load Factors (g)			Load Occurrence (1, 2)
	Longitudinal (3)	Lateral	Vertical	
Truck/Road	±3.5	±2.0	-3.5	I
			+1.5	I
Barge/Water	±5.0	±2.5	-2.5	I
Dolly/Land	±1.0	±0.75	-2.0	I
Air Freight	±3.5	±3.5	-3.5	I
Fork Lifting	±1.0	±0.5	-2.0	S
Hoisting	0	0	-1.5	I

Notes:
(1) S = Loads Occur Simultaneously in the Three Directions
(2) I = Loads Occur Independently in the Three Directions (Except For Gravity)
(3) Longitudinal = Along the Axis of Motion

4.12.2 Ground Handling Shock Criteria

Payload components that have the potential to create a flight safety hazard if damaged during handling and transportation (including fracture-critical parts or components) shall be analyzed, in accordance with SSP 52005, for the drop requirements defined in FED-STD-101, Methods 5005.1, 5007.1, or 5008.1. In lieu of this federal standard, the PD shall evaluate the payload using a shock environment represented by 20 g sawtooth shock pulses (having a 10-ms duration along both directions of each of three orthogonal axes). These analyses shall evaluate the flight hardware in the shipping container configurations.

4.13 Microgravity Disturbances

The SSP 57000 requirements limit the amount of disturbances emanating from any rack into the ISS. It does not distinguish between disturbances created inside the racks and/or science experiments. In addition, it commits the ISS to the level of disturbances allowed to enter the rack.

The following sections describe the environment that the CIR will provide to the payload and the microgravity requirements that the CIR will place on the payload in order for the CIR to meet SSP 57000 requirements.

These requirements are separated into the quasi-steady category for frequencies below 0.01 Hz, the vibratory category for frequencies between 0.01 Hz and 300 Hz, and the transient category.

4.13.1 Rack to Combustion Chamber Insert Interface Microgravity Environment

The following sections describe the maximum microgravity environment that a payload insert can expect at its interface with the Combustion Chamber rails.

4.13.1.1 CIR Quasi-Steady Environment

The maximum quasi-steady (frequency < 0.01 Hz) loads at the payload interface will not exceed the ISS system requirement for assembly complete configuration during the 30-day microgravity modes. The ISS system requirements for quasi-steady loads are defined in SSP 41000, paragraph 3.2.1.1.4.1. The microgravity payload components will be limited to:

1. Quasi-steady acceleration magnitude less than or equal to 1μg.
2. The component perpendicular to the orbital average acceleration vector less than or equal to 0.2 μg.

The CIR will not contribute any additional quasi-steady loads.

4.13.1.2 CIR Vibratory Environment

The vibratory frequency range is defined between 0.01 – 300 Hz. Payload components will be compatible with the maximum expected vibratory accelerations for CIR to its payload interface as defined with the solid curve (CIR Total Generic) shown in FIGURE 62. For reference, the dotted curve shows the interface environment with the full payload allocation described in section 4.13.2.2 of this document, in addition to the CIR generic levels.

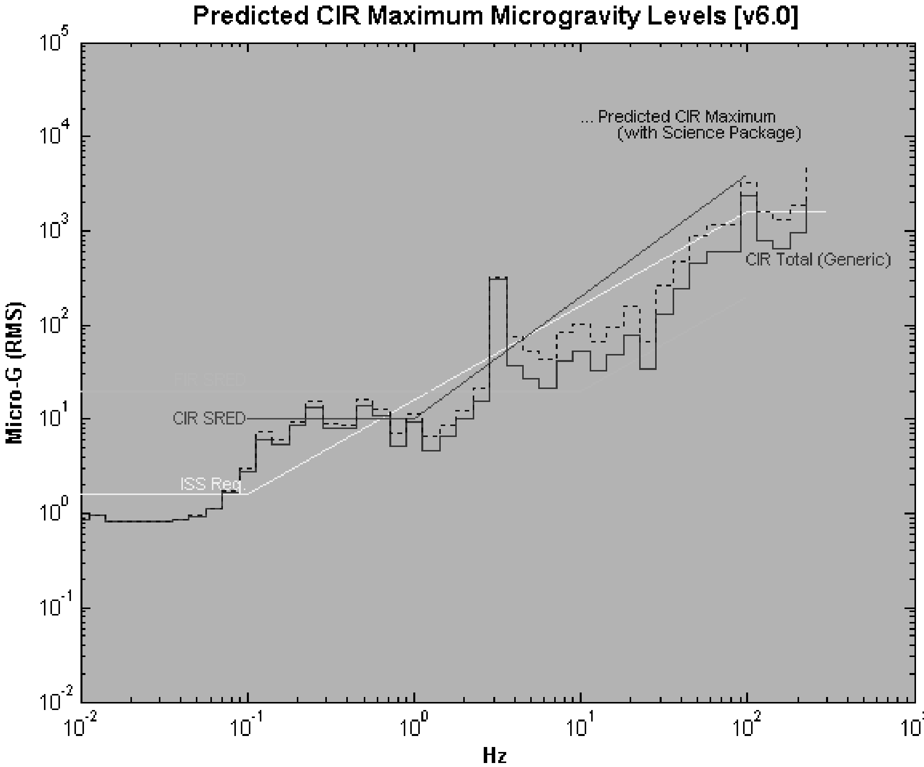


FIGURE 62 CIR TO PAYLOAD INTERFACE MICROGRAVITY ENVIRONMENT

4.13.2 Payload Microgravity Disturbance Limit

The maximum microgravity environment a payload is allowed to transmit to the Combustion Chamber rails is described below.

4.13.2.1 Payload Quasi-Steady Limit

For frequencies below 0.01 Hz, payload components shall limit unbalanced translational average impulses to less than 2 lbs-sec within any 10 to 500 second period in any direction. This translates to 20% of the quasi-steady limits for the entire rack as defined in SSP 57000, section 3.1.2.1.

4.13.2.2 Payload Vibratory Disturbance Limit

The PD shall ensure that the vibratory response to cyclical and transient disturbances is below the Root Sum Squared (RSS) force limit defined by the curve shown in FIGURE 63.

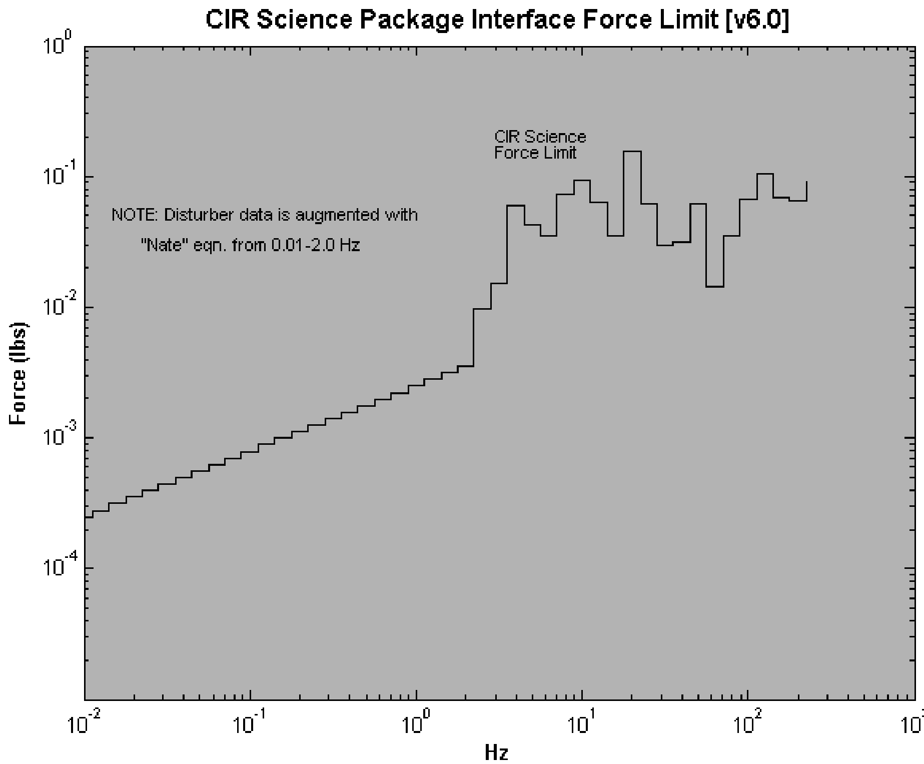


FIGURE 63 CIR RSS FORCE LIMIT

4.13.2.3 Payload Transient Impulse Limit

The payload shall keep its total combined transient impulses under 2.0 lb-sec in any direction over a 10 second period. The payload shall keep its peak load under 200 lb, or 20% of the entire integrated rack allowance of 1000 lb, or 10 lb-sec over a 10 second period as defined in SSP 57000, section 3.1.2.3.

4.14 Constraints for PaRIS Operation of CIR

Payload components will not require physical access from the flight crew while the Passive Rack Isolation System (PaRIS) is unlocked. This includes operation of switches, keypads, latches, doors, dials, or any other device that the flight crew must physically contact.

5.0 THERMAL/FLUIDS INTERFACE

5.1 Optics Bench

5.1.1 Universal Mounting Locations

5.1.1.1 Universal Mounting Location Mounting Holes

N/A

5.1.1.2 Universal Mounting Location Electrical Connector

N/A

5.1.1.3 Universal Mounting Location Air-Cooling Interface

The rack-provided avionics cooling air is forced through an air/liquid heat exchanger to remove waste heat and then directed into the Optics Bench. From the Optics Bench the cooling air flows through UML-mounted payload components and into the void volume of the rack as shown in FIGURE 64.

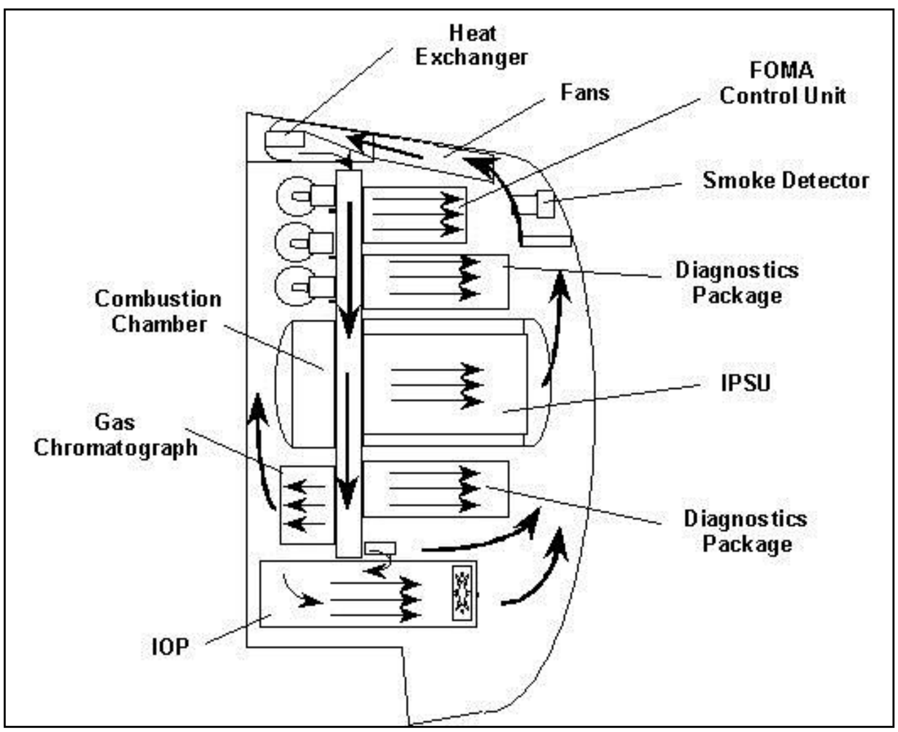


FIGURE 64 CIR AVIONICS AIR-COOLING FLOW

5.1.1.3.1 Airflow Rate to Universal Mounting Location Mounted Components

UML-mounted payload components shall be compatible with a flow-rate equal to 3.111 E-03 m^3/min (0.11 cfm) per watt of package power dissipation. Payload components using UML cooling shall be limited to a flow-rate of 1.4 m^3/min (equivalent to 450 W heat rejection) while keeping within the total heat rejection requirement in section 5.1.1.3.2 of this document and the power availability per payload mounting location described in TABLE 43 .

5.1.1.3.2 Air Supply Temperature to Universal Mounting Location Mounted Components

UML-mounted payload components will be compatible with the air inlet (Air Thermal Control Unit (ATCU) exit) temperatures in the range of 20-30°C (68-86°F). Average tested Heat Exchanger results are shown in FIGURE 65. The ATCU exit temperature is based on the total heat rejection for the rack and a maximum air-cooling capability of approximately 1650 W.

Note: The CIR Heat Exchanger will accommodate additional cooling with warmer air supply temperatures. If the payload requires additional air-cooling, FIGURE 65 can be used to extrapolate preliminary air supply temperatures.

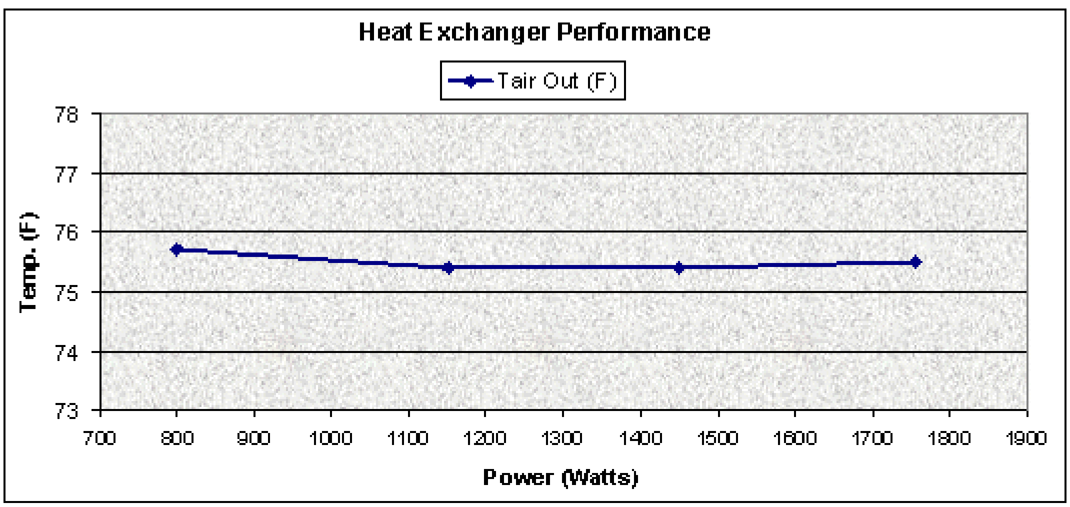


FIGURE 65 AIR SUPPLY TEMPERATURE AT A UML

5.1.1.3.3 Pressure Drop Across Universal Mounting Location Mounted Components

UML-mounted components shall have a flow impedance that yields a 100 ±12.5 Pa (0.4 ±0.05 in H_2O) pressure drop at the design flow rate computed as defined in section 5.1.1.3.1 of this document. This pressure drop requirement applies to the complete UML-mounted package, not to individual components. Additional payload components that utilize rack-provided hardware must be designed such that the component, when incorporated into the completed diagnostics package, meets the package pressure drop requirement.

5.1.1.4 FCF Universal Mounting Location Latch Handle Provisions

N/A

5.1.2 Principal Investigator Location

PIL-mounted payload components shall be compatible with the air-cooling interface requirements as defined in section 5.1.1.3 of this document.

5.1.3 Optics Bench Working Volume

5.1.3.1 Airflow Rate to Optics Bench Mounted Components

Payload components shall be compatible with a maximum airflow rate circulated through the rack of 185 cfm.

Payloads shall be compatible with an Airflow (cfm) = 0.11 x Total Rack Air Cooled Power Dissipation (W), where the total rack air cooled power is equal to the maximum air cooled power for any particular experiment configuration, including hardware that remains unpowered during an experiment.

5.1.3.2 Maximum Allowable Heat Dissipation from Optics Bench Mounted Components

The maximum allowable heat rejection to the cooling air from CIR core hardware, CIR configurable hardware, and payload components shall not exceed 1650 W. The CIR hardware air- and water-cooled heat loads are provided in TABLE 26 .

5.1.3.3 Limitations on Heat Conducted to Structure for Optics Bench Mounted Components

Payload components mounted to the Optics Bench should be designed to ensure that waste heat is rejected to the cooling air or cooling water as the primary heat sink, and therefore it is not necessary to account for heat conduction through Optics Bench mounting structures. Payload component designs should limit their total heat rejection through the Optics Bench attachment structures to 5% or less of the total heat rejected. A minimum of 95% of the total payload component heat load shall be removed by air or water and not conduction.

TABLE 26 CIR HARDWARE HEAT LOADS

CIR Hardware Name	Air-Cooled Heat Load (W)	Water-Cooled Heat Load (W)
CIR Core Hardware (Full) [(1)]	487	106
CIR Core Hardware (Downlink) [(2)]	163	83
CIR Configurable Hardware:	--	--
CIR HiBMS Imaging Package [(3)]	54	
CIR HFR/HR Imaging Package [(3)]	54	
CIR ICM	24	
CIR LLL-UV Imaging Package [(3)]	49	
CIR LLL-IR Imaging Package [(3)]	58	
FCF DCM	23	
FCF IPSU	110	
FCF IPSU-Analog	110	

Notes:

(1) CIR core hardware includes: FCF I/O Processor, ATCU, FCF EPCU, Environmental Control System Electronic Unit (EEU), Fire Detection and Suppression Subsystem (FDSS), Station Support Computer (SSC), Space Acceleration Measurement System (SAMS), and Water Flow Control Assembly (WFCA). Cable loss included with air-cooled total. FCF EPCU loss included with water-cooled total.

(2) Downlink hardware includes FCF I/O Processor, WFCA, EEU, SSC, and FDSS. Cable loss included with air-cooled total. FCF EPCU loss included with water-cooled total.

(3) Includes FCF DCM

5.2 Combustion Chamber

5.2.1 Interface Resource Ring

5.2.1.1 CIR Manifold #3 Interface

Typically, the ISS gaseous nitrogen or payload-provided bottled gases are supplied to the Combustion Chamber through the Static Mixer Gas Supply Interface. The flow and pressure are regulated by the FOMA. This interface is available for the case where the ISS-provided nitrogen or payload-provided bottled gases must be regulated prior to delivery to the Combustion Chamber. The requirements for using this interface are defined in the subsequent sections.

5.2.1.1.1 CIR Manifold #3 Quick-Disconnect Fitting

The physical connection to the CIR Manifold #3 Quick-Disconnect Fitting has been defined in section 3.2.1.1 of this document.

5.2.1.1.2 CIR Manifold #3 Temperature

The payload-provided bottled gases will be supplied to the CIR Manifold #3 within the range of 5 to 45 ºC (41 to 113 ºF).

5.2.1.1.3 CIR Manifold #3 Maximum Pressure

The payload-provided bottled gases supplied to the CIR Manifold #3 will not exceed a pressure of 11,825 kPa (1,716 psia) at standard temperature.

5.2.1.1.4 Gaseous Nitrogen Flow Rate

The PD shall ensure that the payload limits the flow rate of ISS GN_2 per the requirements specified in SSP 57000, section 3.7.1.1.

5.2.1.1.5 Gaseous Nitrogen Supply Temperature

Payload components will be compatible with the ISS GN_2 supplied within the initial temperature range as specified in SSP 57000, section 3.7.1.3.

5.2.1.1.6 Gaseous Nitrogen Supply Pressure

Payload components shall be compatible with ISS GN_2 supplied within the pressure range specified in SSP 57000, section 3.7.1.1.

5.2.1.1.7 Gaseous Nitrogen Quality

Payload components will be compatible with the quality of the ISS GN_2 as defined in SSP 30573, Table 4.1-2.13.

5.2.1.2 Static Mixer Gas Supply Interface

The Static Mixer Gas Supply Interface provides regulated gas supply from the CIR Manifold #1, CIR Manifold #2 and CIR Manifold #3. This interface can be utilized to introduce premixed or dynamically blended gases into the Combustion Chamber or for partial pressure gas blending within the Combustion Chamber. The requirements for using this interface are defined in subsequent sections.

5.2.1.2.1 Static Mixer Gas Supply Quick-Disconnect Fitting

The physical connection to the Static Mixer Gas Supply Quick-Disconnect Fitting has been defined in section 3.2.1.2.1 of this document.

5.2.1.2.2 Static Mixer Gas Flow Rate Supplied by the CIR Manifold #3, CIR Manifold #1 and CIR Manifold #2

Payload components will be compatible with the gaseous flow rates supplied to the Combustion Chamber in the range of 0 to 30 slpm nitrogen at the calibrated temperature with an accuracy of ±0.3 slpm at each of the three manifolds.

5.2.1.2.3 Total Static Mixer Gas Flow Rate

Payload components will be compatible with the total gaseous flow control to the Combustion Chamber in the range of 0 to 90 slpm nitrogen at the calibrated temperature with an accuracy ±0.9 slpm.

5.2.1.2.4 Static Mixer Gas Supply Temperature

Payload components will be compatible with the gases supplied within the temperature range of 5 to 45 ºC (41 to 113 ºF).

5.2.1.2.5 Static Mixer Gas Supply Pressure

Payload components will be compatible with static mixer gas supplied within the pressure range of 2.02 kPa to 931 kPa (0.294 psia to 135 psia).

5.2.1.2.6 Gaseous Nitrogen Quality

Payload components that utilize the ISS GN_2 through the CIR Manifold #3, will be compatible with the quality of the nitrogen as specified in section 5.2.1.1.7 of this document.

5.2.1.3 CIR Manifold #4 Interface

The requirements for use of the bottled gas supply from the CIR Manifold #4 (Fuel/Premixed Fuel Supply Manifold) are defined in subsequent sections.

5.2.1.3.1 CIR Manifold #4 Quick-Disconnect Fitting

The physical connection to the CIR Manifold #4 (Fuel/Premixed Gas Quick-Disconnect Fitting) has been defined in section 3.2.1.3.1 of this document.

5.2.1.3.2 CIR Manifold #4 Flow Rate

Payload components will be compatible with the gaseous flow rate to the Combustion Chamber in the range of 0 to 2 slpm propane, at the calibrated temperature, with an accuracy of ±0.02 slpm.

5.2.1.3.3 CIR Manifold #4 Temperature

Payload components will be compatible with the gases supplied within the temperature range of 5 to 45 ºC (41 to 113 ºF).

5.2.1.4 Gas Chromatograph Interface

The GC is capable of measuring, at a minimum, the following gas constituents: hydrogen, methane, propane, oxygen, nitrogen, carbon dioxide, carbon monoxide and sulfur hexafluoride. Gas constituent concentrations are capable of being measured in the range from 0.1 to 98% with a precision of ±2% of reading for constituents with dissimilar retention times and utilizing an optimized method for retention.

5.2.1.4.1 Gas Chromatograph Quick-Disconnect Fitting

The physical connection to the GC Quick-Disconnect Fitting has been defined in section 3.2.1.4.1 of this document.

5.2.1.4.2 Gas Sample Pressure

Gases supplied to the GC for analysis will be in the pressure range of 50.5 to 304 kPa (7.35 to 44.1 psia).

5.2.1.4.3 Gas Oxygen Concentration

Gases supplied to the GC for analysis will not exceed an oxygen concentration of 85%.

5.2.1.5 Electrical Feed-Throughs

N/A

5.2.1.6 Principal Investigator Port

N/A

5.2.1.7 Vacuum Exhaust Port

N/A

5.2.1.8 Combustion Chamber Grounding Interface

N/A

5.2.2 CIR Rear End-Cap Port Plug Interface

N/A

5.2.3 Rear Access Port

N/A

5.2.4 Window Ports

N/A

5.2.5 Mounting Rails

N/A

5.2.6 Axial Locating Slots

N/A

5.2.7 Vacuum Exhaust System Interface

The Combustion Chamber is capable of being evacuated through the EVP using solenoid valves actuated by the FOMA Control Unit. Alternatively, manual valves can be configured to allow venting such that the EVP is bypassed. The physical interface to the VES Interface is described in section 3.2.7 of this document.

5.2.7.1 Vacuum Exhaust System Input Temperature Range

Payload components that vent exhaust gases will limit the initial temperature to the range specified in SSP 57000, section 3.6.1.3.

5.2.7.2 Exhaust Gas Flow Rate when Not Using the CIR Adsorber Cartridge

Payload components will be compatible with the total gaseous flow control exiting the Combustion Chamber in the range of 0 to 90 slpm nitrogen at the calibrated temperature with an overall accuracy ±0.9 slpm when bypassing the CIR Adsorber Cartridge and exiting to the VES through the EVP.

5.2.7.3 Exhaust Gas Flow Rate when Using the CIR Adsorber Cartridge

Payload components will be compatible with the total gaseous flow control exiting the Combustion Chamber in the range of 0 to 18 slpm with an overall accuracy ±0.9 slpm when flowing through the CIR Adsorber Cartridge to the VES.

5.2.7.4 Vacuum Exhaust System Acceptable Gases

Payload components shall meet the exhaust gas requirements of SSP 57000, sections 3.6.1.5, 3.6.1.5.1 A, and 3.6.1.5.2. A list of acceptable gases that are compatible with the VES is specified in SSP 57000 Appendix D, Table D1. A list of unacceptable gases that are not compatible with the VES is specified in SSP 57000, Appendix D, Table D2. The payload may not vent above an oxygen concentration of 28%.

5.2.7.5 Vacuum Exhaust System External Contamination Control

Exhaust gases vented into the VES by the payload components shall be compatible with section 3.4 of SSP 30426.

5.2.7.6 Vacuum Exhaust System Non-Reactive Gases

Exhaust gases vented into the VES by the payload components shall be non-reactive with other vent gas constituents as specified in SSP 57000, section 3.6.1.5 B.

5.2.7.7 Vacuum Exhaust System Particulate Removal

Payload components shall remove particulates as specified in SSP 57000, section 3.6.1.5 D, from the gases prior to exhausting to the VES, unless the gas flows through the CIR Adsorber Cartridge or venting is accomplished through the manual vent configuration.

5.2.7.8 Vacuum Exhaust System Input Dew Point

Payload components will limit vented exhaust gases to a maximum initial dew point temperature in the range specified in SSP 57000, section 3.6.1.4.

5.2.7.9 Vacuum Exhaust System Oxygen Concentration Venting

The PD shall provide an analysis of the free volume of the Combustion Chamber with the experiment installed versus oxygen bottle size, concentration and pressure such that if the entire oxygen bottle contents were dumped into the Combustion Chamber, the Combustion Chamber MDP of 135 psia would allow the Combustion Chamber oxygen concentration to be diluted below 28%.

5.2.8 Vacuum Resource System Interface

The physical interface to the VRS Interface is provided at the Rack UIP as described in section 3.2.8 of this document.

5.2.8.1 Vacuum Resource System Throughput Limit

The combined payload components gas throughput to the VRS shall not exceed the limits specified in SSP 57000, section 3.6.2.3.

5.2.8.2 Vacuum Resource System Input Pressure Limit

Payload components shall limit vented exhaust gas to the VRS to the maximum pressure specified in SSP 57000, section 3.6.2.2 A.

5.2.8.3 Vacuum Resource System Maximum Design Pressure and Failure Tolerance

Payload components that utilize the VRS shall be designed to the MDP as specified in SSP 57000, section 3.6.2.2 B and shall have failure tolerance as specified in SSP 57000 section 3.6.2.2 C.

5.2.8.4 Vacuum Resource System Acceptable Gases

The payload gases vented through the VRS shall meet the requirements stated for the VES in section 5.2.7.4 of this document.

5.3 Fuel/Oxidizer Management Assembly

5.3.1 Pressure Control

Payload components will be compatible with an initial static gas pressure within the Combustion Chamber in the range of 2.03 to 304 kPa (0.294 to 44.1 psia) and an accuracy of ±0.252 kPa (± 0.037 psia) at the calibrated temperature.

Payload components will be compatible with a dynamic gas pressure of 1 atmosphere within the Combustion Chamber controlled to an accuracy of +/- 5% at the calibrated temperature.

5.3.2 Gas Blending

5.3.2.1 Partial Pressure Gas Blending of Binary and Tertiary Mixtures

Payload components will be compatible with the partial pressure blending of an ideal binary or tertiary gas mixture with a precision of ±25.3%-kPa (±3.68%-psia) absolute at calibrated conditions. To determine process precision at a specific total pressure, divide the above blending precision by the total pressure in the appropriate units.

5.3.2.2 Dynamic Gas Blending of Binary and Tertiary Mixtures

Payload components will be compatible with the dynamic blending of a binary or tertiary gas mixture to a ±1% absolute within the range of 0 to 100%.

5.3.3 Oxidizer Control During Combustion Events

During combustion events when the oxidizer replenishment rate is less than 0.02 mole/sec and the total oxidizer replenishment does not exceed 600 grams, the CIR and the payload components shall provide a constant oxidizer concentration within the Combustion Chamber to a precision of at least ±0.0002 mole/sec. This assumes that both the instantaneous oxygen concentration measurement and the desired set point oxygen concentration are provided by the payload to the FOMA.

5.3.4 Elimination of Toxic Materials

Payload experiments that produce toxic test points shall remove the toxic materials to acceptable levels prior to venting. Acceptable levels are defined in section 5.2.7.4 of this document.

5.4 CIR-Provided Diagnostics

5.4.1 FCF Diagnostic Control Module

5.4.1.1 FCF Diagnostic Control Module Kinematic Mount

N/A

5.4.1.2 FCF Diagnostic Control Module Air-Cooling Port

5.4.1.2.1 Airflow Rate to FCF Diagnostic Control Module Mounted Components

FCF DCM-mounted payload components shall be compatible with the airflow rate as specified for UML-mounted payload components in section 5.1.1.3.1 of this document.

5.4.1.2.2 Air Supply Temperature to FCF Diagnostic Control Module Mounted Components

FCF DCM-mounted payload components will be compatible with the avionics cooling air as specified for UML-mounted payload components in section 5.1.1.3.2 of this document.

5.4.1.2.3 Pressure Drop across FCF Diagnostic Control Module Mounted Components

The combined flow impedance of the FCF DCM-mounted components and the FCF DCM shall be identical to that specified for the UML-mounted components in section 5.1.1.3.3 of this document, at the air flow rate per section 5.1.1.3.1 of this document. The pressure drop of the FCF DCM at various airflow rates is shown in FIGURE 66.

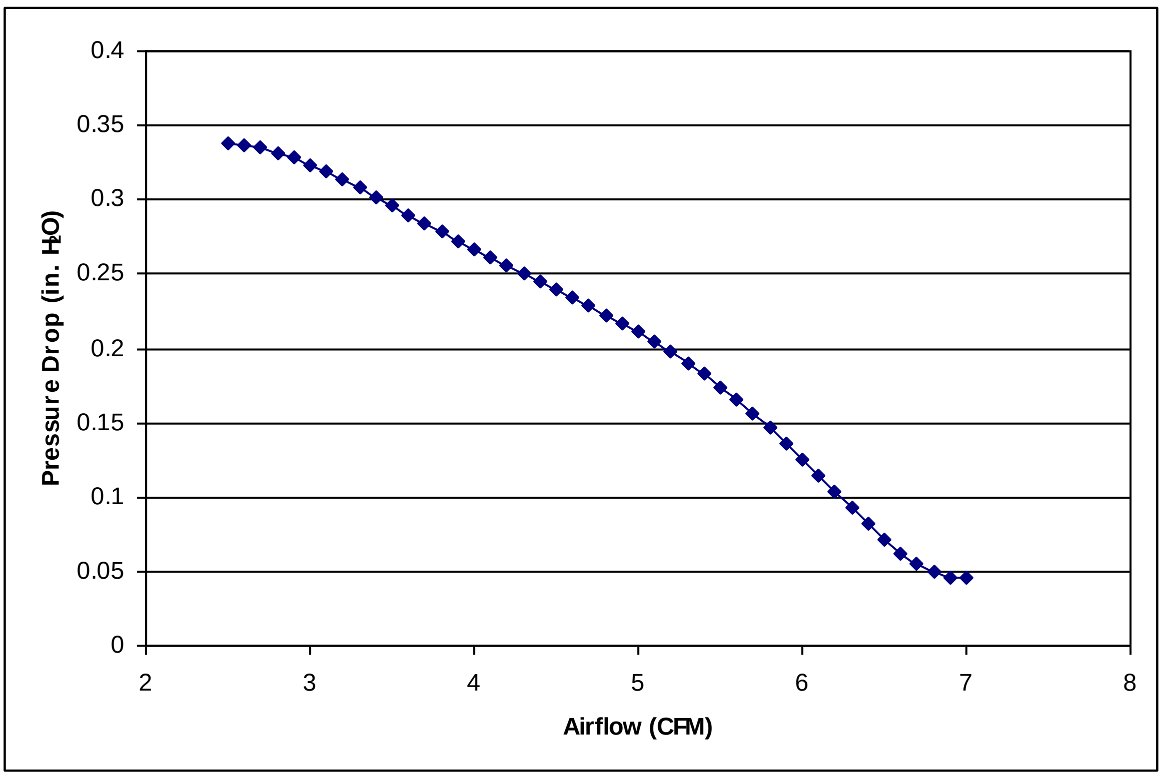


FIGURE 66 FCF DCM PRESSURE DROP VERSUS AIRFLOW RATE

5.4.1.3 <u>FCF Diagnostic Control Module Electrical Connector</u>

N/A

5.4.2 CIR High Bit Depth/Multispectral Imaging Package

N/A

5.4.3 CIR High Frame Rate/High Resolution Imaging Package

N/A

5.4.4 CIR Low Light Level Ultraviolet Imaging Package

N/A

5.4.5 CIR Low Light Level Infrared Imaging Package

N/A

5.4.6 CIR Optics Housing Module

5.4.6.1 CIR Optics Housing Module Air-Cooling Port

5.4.6.1.1 Airflow Rate to CIR Optics Housing Module Mounted Components

CIR Optics Housing Module mounted payload components shall be compatible with the airflow rate as specified in section 5.1.1.3.1 of this document.

5.4.6.1.2 Air Supply Temperature to CIR Optics Housing Module Mounted Components

CIR Optics Housing Module mounted payload components will be compatible with the avionics cooling air as specified for UML-mounted payload components in section 5.1.1.3.2 of this document.

5.4.6.1.3 Pressure Drop across CIR Optics Housing Module Mounted Components

The combined flow impedance of the CIR Optics Housing Module mounted payload components and the FCF DCM shall be identical to that specified for UML-mounted payload components in section 5.1.1.3.3 of this document, at the airflow rate in section 5.1.1.3.1 of this document. **<TBD 05-01>**

5.4.6.2 CIR Optics Housing Module Electrical Connector

N/A

5.4.7 CIR Illumination Control Module

N/A

5.4.8 FCF Image Processing and Storage Unit

N/A

5.4.9 FCF Image Processing and Storage Unit – Analog

N/A

5.5 120 VDC Power Interface

N/A

5.6 Cooling Water Interface

The requirements for use of the Cooling Water Interface are defined in subsequent sections.

5.6.1 Cooling Water Quick-Disconnect Fitting

The physical connection to the Optics Bench Cooling Water Quick-Disconnect Fitting has been identified in section 3.1.3.3.1 of this document and the Combustion Chamber Cooling Water Interface Quick-Disconnect Fitting has been defined in section 3.2.1.5.1 of this document.

5.6.2 Cooling Water Flow Rate

The flow rate of cooling water to the payload is CIR-regulated based on heat rejection into the water loop by the payload. The payload shall be compatible with a cooling water flow rate of 25 lb/hr for heat loads of 183.4 W or less. For heat loads greater than 183.4 W, the payload shall be compatible with the flow rate of 0.1367 lb/hr for each Watt of heat ±15 lb/hr, to a CIR total maximum of 430 lb/hr.

Note: The maximum coolant flow rate of 430 lb_m/hr corresponds to 4 kW of heat rejection that is allocated to the entire rack. When estimating the coolant allocation, the PD shall take into account the power consumption and required coolant of the other CIR components. Due to operational considerations and water-cooling loop hardware limitations, a minimum of 200 W of payload heat rejection is desirable.

5.6.3 Cooling Water Supply Temperature

Payload components will be compatible with cooling water supply temperature in the range of 16.0 to 18.3 ºC (61 to 65 ºF).

5.6.4 Cooling Water Return Temperature

Payload components shall ensure that the secondary loop cooling water return temperature does not exceed 49 °C (120 °F).

5.6.5 Cooling Water Differential Pressure

The cooling water maximum allowable pressure drop across the payload components, based on the total cooling water flow, including the mating QD fittings and flexible hoses, shall not exceed the CIR Allocation to PD Pressure Drop values shown in FIGURE 67.

5.6.6 Cooling Water Materials Compatibility

Payload components connecting to the cooling water interface shall use fluids that meet the materials requirements and system cleanliness levels specified in SSP 57000 section 3.11.2.

Payload components shall consist of internal wetted materials that are compatible with the requirements identified in section 12.2 of this document.

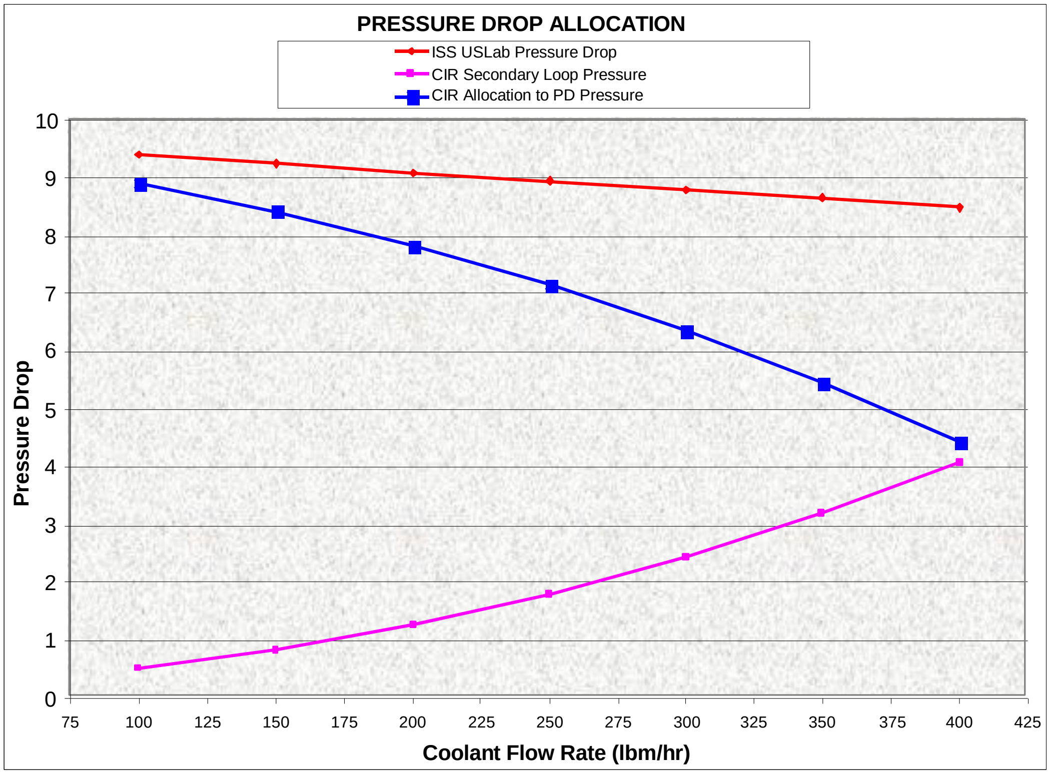


FIGURE 67 CIR COOLING WATER MAXIMUM ALLOWABLE PRESSURE DROP

5.6.7 Cooling Water Charging

The payload shall be delivered on-orbit fully charged with cooling water as specified in SSP 57000, section 3.5.1.2.

5.6.8 Cooling Water Thermal Expansion

During transportation and stowage to/from the ISS, the payload components charged with cooling water shall provide the capability to compensate for thermal expansion due to temperature fluctuations between 1.67 and 46°C (35 to 114.8°F).

When on-orbit, but not attached to the ISS Moderate Temperature Loop (MTL), the payload components charged with cooling water shall provide the capability to compensate for thermal expansion between the temperatures of 16.1 and 46°C (61 to 114.8°F).

5.6.9 Total Quantity of Cooling Water within the Payload Components

The total quantity of cooling water contained in the payload components during operations, including hoses and fittings, shall not exceed 0.69 L.

5.6.10 Cooling Water Leakage Rate

The total allowable leakage of cooling water (liquid phase) by the payload components shall not exceed 0.014 scc/hr of water at the MDP as specified in section 5.6.11 of this document.

5.6.11 Cooling Water System Maximum Design Pressure

Payload components that utilize cooling water shall be designed to an MDP of 834 kPa (121 psia) with safety factors in accordance with SSP 52005, section 5.1.3.

5.6.12 Fail Safe Design and Loss of Cooling Water

Payload components that utilize cooling water shall be designed to be fail-safe in the case of loss of cooling water for all modes of operation per SSP 57000, section 3.5.1.8.

5.7 Government Furnished Accumulator

The PD may use the GFE Accumulator in order to meet the thermal expansion requirements stated in section 5.6.8 of this document, during transportation and stowage. The physical/mechanical characteristics of this device are provided in section 3.2.1.6 of this document.

6.0 ELECTRICAL POWER AND DATA INTERFACES

6.1 Optics Bench

6.1.1 Universal Mounting Locations

6.1.1.1 Universal Mounting Location Mounting Holes

N/A

6.1.1.2 Universal Mounting Location Electrical Connector

The pin assignments for UMLs 1, 2, 4, 6 and 8 differ from UMLs 3, 5, and 7. The pin assignments are provided in TABLE 27 and TABLE 28 for UMLs 1, 2, 4, 6 and 8 and in TABLE 29 and TABLE 30 for UMLs 3, 5, and 7. The UML electrical connector part number and the payload-provided mating connector part number are identified in section 3.1.1.3 of this document. The locations of the various UMLs on the Optics Bench are shown in FIGURE 2 and the location of the bays is shown in FIGURE 1. The characteristics of each electrical interface are provided in subsequent sections.

TABLE 27 PINOUT CONFIGURATIONS FOR UMLS 1, 2, 4, 6, AND 8 BAY A

Pin #	Signal
1	Ethernet 1 Transmit Data +
2	Ethernet 1 Transmit Data -
3	Ethernet 1 Receive Data +
4	Ethernet 1 Receive Data -
7	SYNC 1
8	SYNC 1 RTN
13	FCF IPSU Video +
14	FCF IPSU Video -
17	CAN Bus +
18	CAN Bus -
19	CAN Bus +
20	CAN Bus -
26-35	To JOPB9 PI Configurable
53	Location Address Bit 0 LSB
54	Bit 1
55	Bit 2
56	Bit 3
57	Bit 4
58	Location Address Bit 5 MSB
59	Ground From Device

Pin #	Signal
94	Redundant SYNC 1
95	Redundant SYNC 1 RTN
99	Redundant CAN Bus +
100	Redundant CAN Bus -
101	Redundant CAN Bus +
102	Redundant CAN Bus -

TABLE 28 PINOUT CONFIGURATIONS FOR UMLS 1, 2, 4, 6, AND 8 BAY B

Pin #	Signal
21	+28V 8A
22	+28V 8A Return
25	Structure Ground 1
26	Structure Ground 2

TABLE 29 PINOUT CONFIGURATIONS FOR UMLS 3, 5, AND 7 BAY A

Pin #	Signal
1	Ethernet 1 Transmit Data +
2	Ethernet 1 Transmit Data -
3	Ethernet 1 Receive Data +
4	Ethernet 1 Receive Data -
5	SYNC 1
6	SYNC 1 RTN
7	SYNC 2
8	SYNC 2 RTN
9	Ethernet 2 Transmit Data +
10	Ethernet 2 Transmit Data -
11	Ethernet 2 Receive Data +
12	Ethernet 2 Receive Data -
13	FCF IPSU 1 Video +
14	FCF IPSU 1 Video -
15	FCF IPSU 2 Video +
16	FCF IPSU 2 Video -
17	CAN Bus +
18	CAN Bus -
19	CAN Bus +
20	CAN Bus -
21	CAN Bus +
22	CAN Bus -
23	CAN Bus +

Pin #	Signal
24	CAN Bus -
26-35	To JOPB9 PI Configurable
53	Location Address Bit 0 LSB
54	Bit 1
55	Bit 2
56	Bit 3
57	Bit 4
58	Location Address Bit 5 MSB
59	Ground From Device
60	Location Address Bit 0 LSB
61	Bit 1
62	Bit 2
63	Bit 3
64	Bit 4
65	Location Address Bit 5 MSB
66	Ground From Device
94	Redundant SYNC 1
95	Redundant SYNC 1 RTN
96	Redundant SYNC 2
97	Redundant SYNC 2 RTN
99	Redundant CAN Bus +
100	Redundant CAN Bus -
101	Redundant CAN Bus +
102	Redundant CAN Bus -
103	Redundant CAN Bus +
104	Redundant CAN Bus -
105	Redundant CAN Bus +
106	Redundant CAN Bus -

TABLE 30 PINOUT CONFIGURATIONS FOR UMLS 3, 5, AND 7 BAY B

Pin #	Signal
21	+28V 8A
22	+28V 8A Return
23	+28V 8A
24	+28V 8A Return
25	Structure Ground 1
26	Structure Ground 2

6.1.1.2.1 Sync Bus

The FCF provides a programmable Sync Bus for synchronizing diagnostic hardware. The synchronizing clock is a 5 VDC square wave with a 50% duty cycle and is programmable from 0 to 1000 Hz in 5 Hz increments with an accuracy of ±1 Hz. Payload components that interface with the FCF Sync Bus shall be optically isolated from the bus. The opto-coupler shall be chosen so that the current draw from the Sync Bus is 3 mA or less. An example of a Sync Bus interface circuit is shown in FIGURE 68.

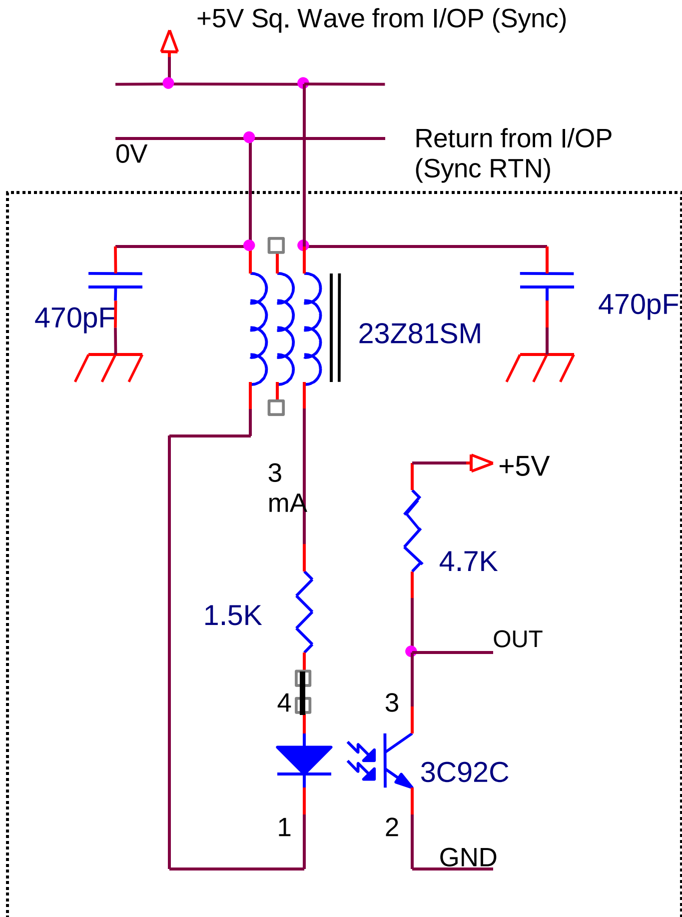


FIGURE 68 EXAMPLE OF A SYNC BUS INTERFACE CIRCUIT

6.1.1.2.2 Analog Video

Payload components that interface to analog video shall meet the electrical specifications of RS-170A (EIA RS-170, EIA RS-170A) for balanced differential analog video. Each UML connector provides an interface for one analog video channel connected to the FCF I/O Processor. Each video channel consists of a differential signal. The differential lines are a twisted shielded pair of 24 American Wire Gauge (AWG) wire with a nominal characteristic impedance of 77 ohms. UML locations supporting two FCF IPSUs are provided with a second analog video channel interface.

6.1.1.2.3 Controller Area Network Bus

The Optics Bench CAN Bus provides command and control of FCF-provided diagnostic hardware and is used to report Health and Status (H&S) data to the FCF I/O Processor.

Payload components that interface with the Optics Bench CAN Bus shall comply with ISO 11898.

6.1.1.2.4 Location Address

Each UML connector on the Optics Bench contains a location address. Payload components that utilize the location address shall provide the ability to read and report the address to the FCF I/O Processor via the CAN Bus or Ethernet.

The Location Address consists of 6 address lines and 1 signal return. The address inputs to the payload components that interface with a UML shall be configured such that any input not connected to signal ground is read as logic high. Payload components interfacing at each UML shall provide 4.7 kilohm pull-up resistors on all 6 lines and a signal return line to use as logic low. The eight UML locations on the CIR have location identifiers corresponding to the binary patterns for numbers 33 – 47 as specified in TABLE 31 . UMLs 3, 5 and 7 each contain two sets of pins for the address with location identifiers 43, 45, and 47, respectively. An example of a circuit utilizing a CAN Bus Address is shown in FIGURE 69.

TABLE 31 BINARY LOCATION IDENTIFICATION/ADDRESS FOR UMLS

UML Designation	Bit Pattern (MSB – LSB)	Decimal Address
JUML1	100001	33
JUML2	100010	34
JUML3A	100011	35
JUML4	100100	36
JUML5A	100101	37
JUML6	100110	38
JUML7A	100111	39
JUML8	101000	40
JUML3B	101011	43
JUML5B	101101	45
JUML7B	101111	47

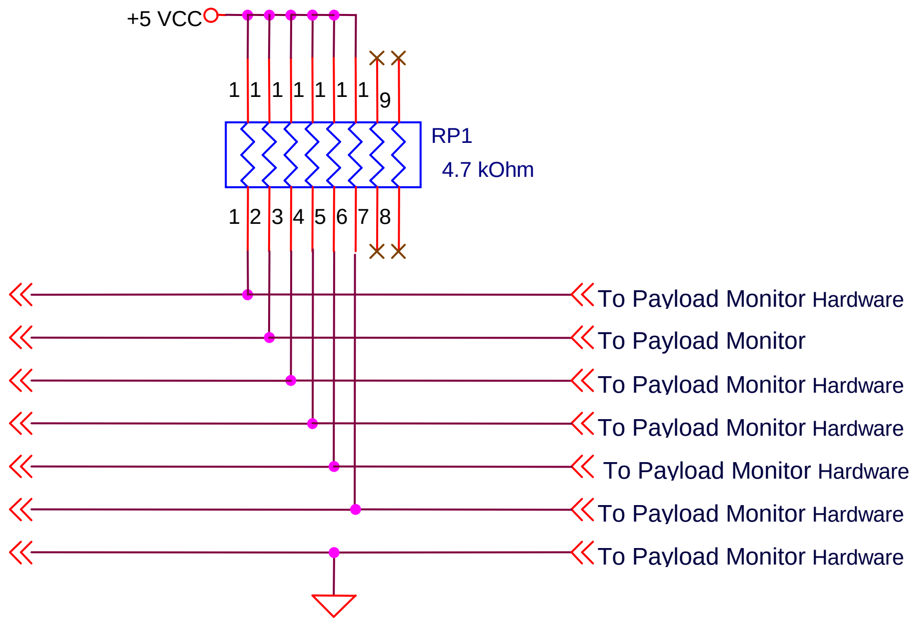


FIGURE 69 EXAMPLE OF A CIRCUIT UTILIZING A CAN BUS ADDRESS

6.1.1.2.5 Ethernet

Payload components that interface with the FCF Ethernet shall comply with IEEE 802.3.

6.1.1.2.6 28 VDC Power

Each UML provides a 28 VDC channel. Payload components shall not exceed a maximum current draw of 8 A with a corresponding return. Each UML provides two chassis ground connections. Payload components shall use the chassis ground by tying each pin to the payload hardware chassis at separate points to ensure crew safety.

6.1.1.2.6.1 Normal Voltage Levels

The payload shall operate and be compatible with the limits of magnitude and duration for the voltage transients at the FCF EPCU output as shown in FIGURE 70. The envelope shown in this figure applies to the transient responses exclusive of any periodic ripple and/or random noise components that may be present.

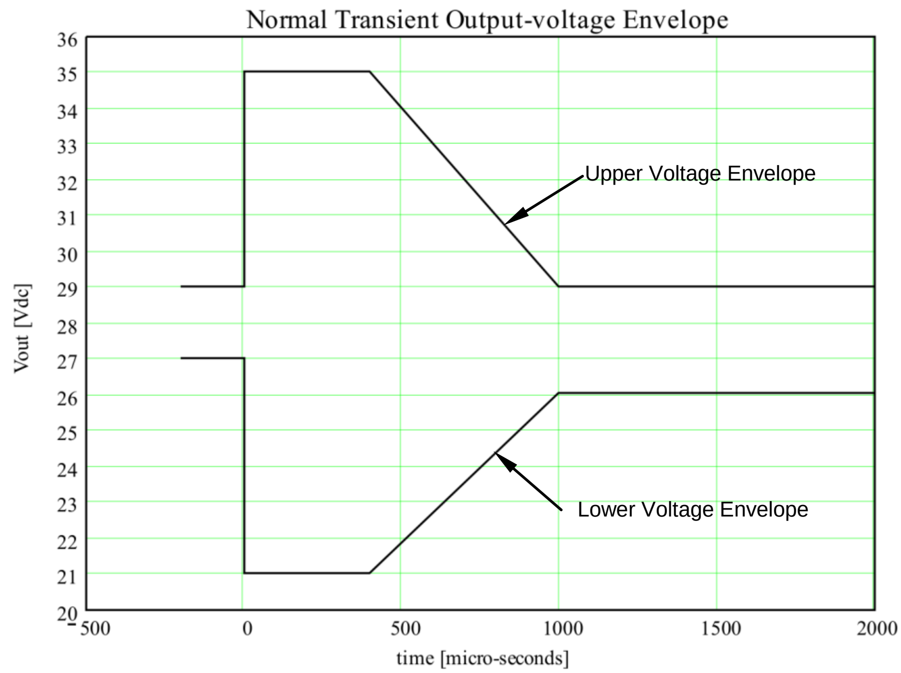


FIGURE 70 28 VDC OUTLET VOLTAGE CHARACTERISTICS

6.1.1.2.6.2 Non-Normal Output Voltage Levels

The payload shall not produce an unsafe condition or one that could result in damage to ISS equipment or to other payload components when subjected to the non-normal FCF EPCU output voltage characteristics shown in FIGURE 71.

6.1.1.2.6.3 Payload Load Input Impedance

Payload components shall be compatible with input impedance limits for loads connected to one channel of the 28 VDC power as shown in FIGURE 72 and FIGURE 73. These limits ensure stability for a load that is connected to one FCF EPCU 4.0 ADC Flexible Remote Power Controller (FRPC) channel. The limits include a magnitude margin of two times the source impedance magnitude as shown in FIGURE 72, and a +/- 45° phase margin about +/- 180° difference from the source phase as shown in FIGURE 73.

The phase restriction does not change with paralleled FRPC channels. However, the magnitude limit curve in FIGURE 72 must be divided by the number of paralleled EPCU channels that feed a given load. In the case of loads connected to 8.0 ADC sources, the limits in FIGURE 72 must be divided by 2.

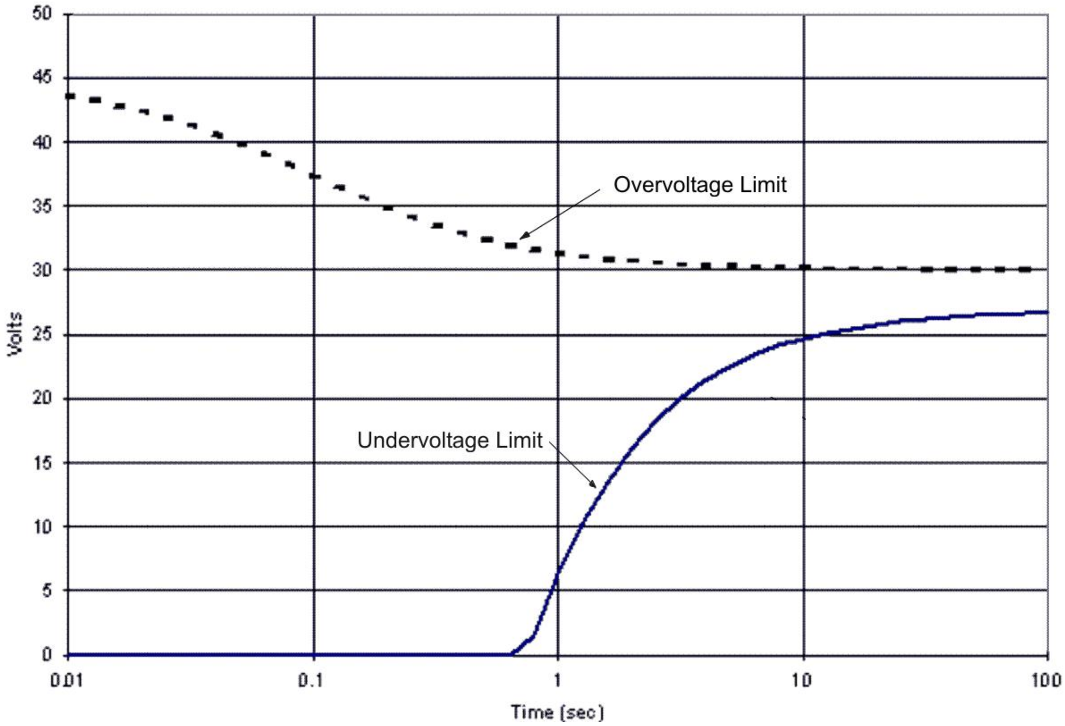
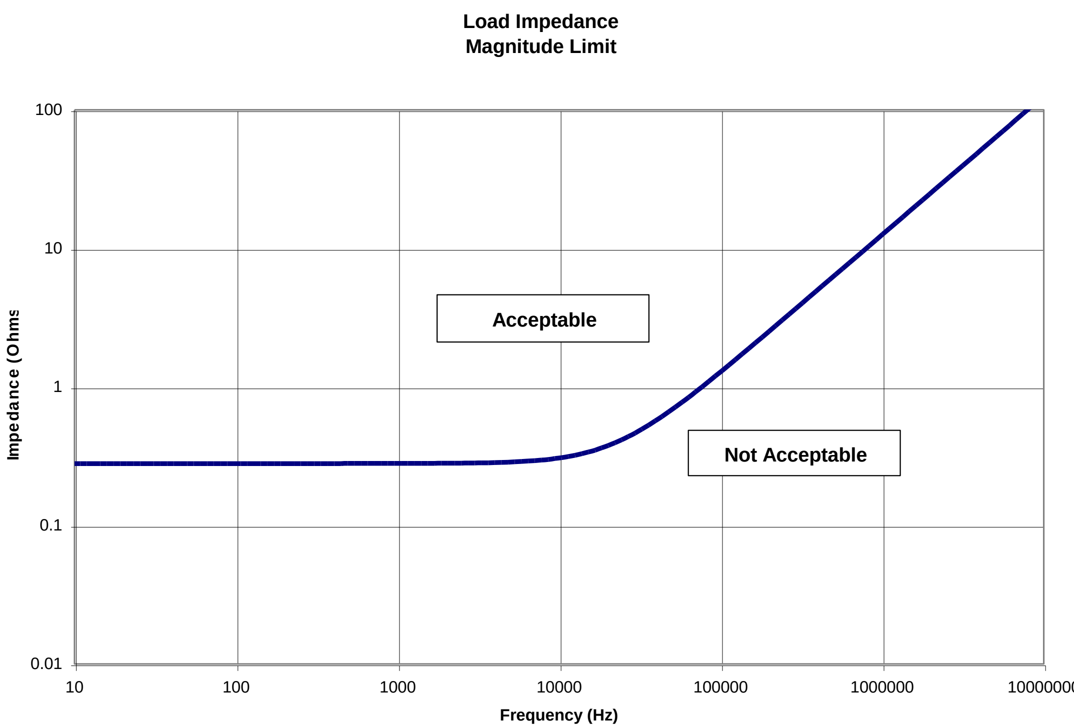


FIGURE 71 NON-NORMAL OUTPUT VOLTAGE CHARACTERISTICS



Note: In case of loads connected to 8.0 ADC sources, the limits in this figure must be divided by 2.

FIGURE 72 LOAD INPUT IMPEDANCE MAGNITUDE LIMITS

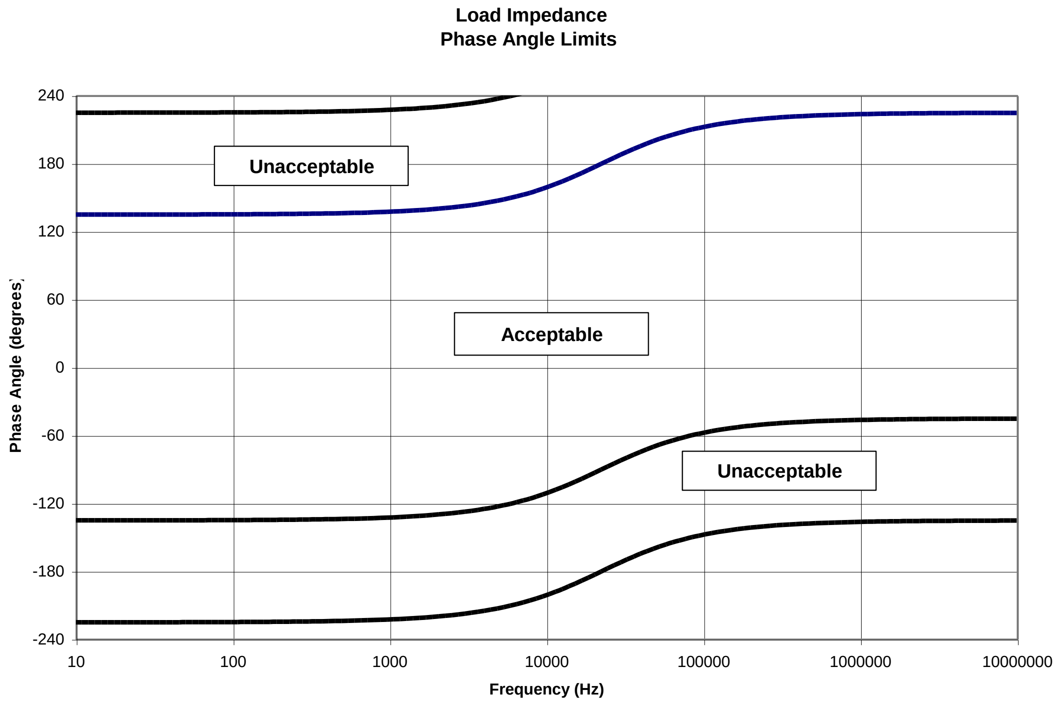


FIGURE 73 LOAD INPUT IMPEDANCE PHASE LIMITS

6.1.1.2.6.4 Ripple Voltage Characteristics

Payload components shall operate and be compatible with a time domain ripple voltage and noise level of 1.4 V_{rms} maximum within the frequency range of 30 Hz to 10 kHz. This level represents the maximum expected ripple voltage that could be caused by other loads on the 28 VDC output.

6.1.1.2.6.5 Reverse Current

Payload components connected to 28 VDC power channels shall meet the following requirements:

- 28 VDC loads that are fed by a single FCF EPCU channel and have an input capacitance higher than 10,000 uF are required to use a diode in series with its input line to prevent reverse energy current flow back into the FCF EPCU.
- If two channels are paralleled, 20,000 uF are allowed before input diodes are required.

A maximum load capacitance of up to 200,000 uF of a purely capacitive load or 100,000 uF with a 4.0 ADC load is allowed per power channel.

6.1.1.2.6.6 Wire Derating

The derating criteria for the payload components downstream of the rack power source shall be per NASA TM 102179 as interpreted by NSTS 18798, TA-92-038.

6.1.1.2.6.7 Power Switches/Controls

The payload power switches and controls shall meet the requirements of SSP 57000, section 3.2.5.3.

6.1.1.2.6.8 Overload Protection

Payload components shall be compatible with the following overload protection characteristics. The FCF EPCU provides current limiting protection as defined below and output voltage limit protection as defined in section 6.1.1.2.6.2 of this document. The PD is responsible for additional overload protection for the payload components.

Payload components, causing an overload or short circuit to the 28 VDC power, shall be compatible with the current limited in the range of 4.2 to 4.6 ADC for each channel connected to the load. The FRPC module controls the output current limiting function. The FRPC can be paralleled up to a maximum of four EPCU channels to attain current-limiting capacities of up to 16 ADC.

For example, if two channels are paralleled, the maximum operating design current draw is 8 A and the circuit will limit the current between 8.4 and 9.2 ADC. If a 2.8 ohm load is applied to the output, the current must be limited to a minimum of 8.4 ADC. This will cause 23.5 VDC to be developed across the load and 4.5 VDC to be developed across the FRPC. This condition will cause the FRPC to trip off in approximately 5.0 seconds as shown in FIGURE 74.

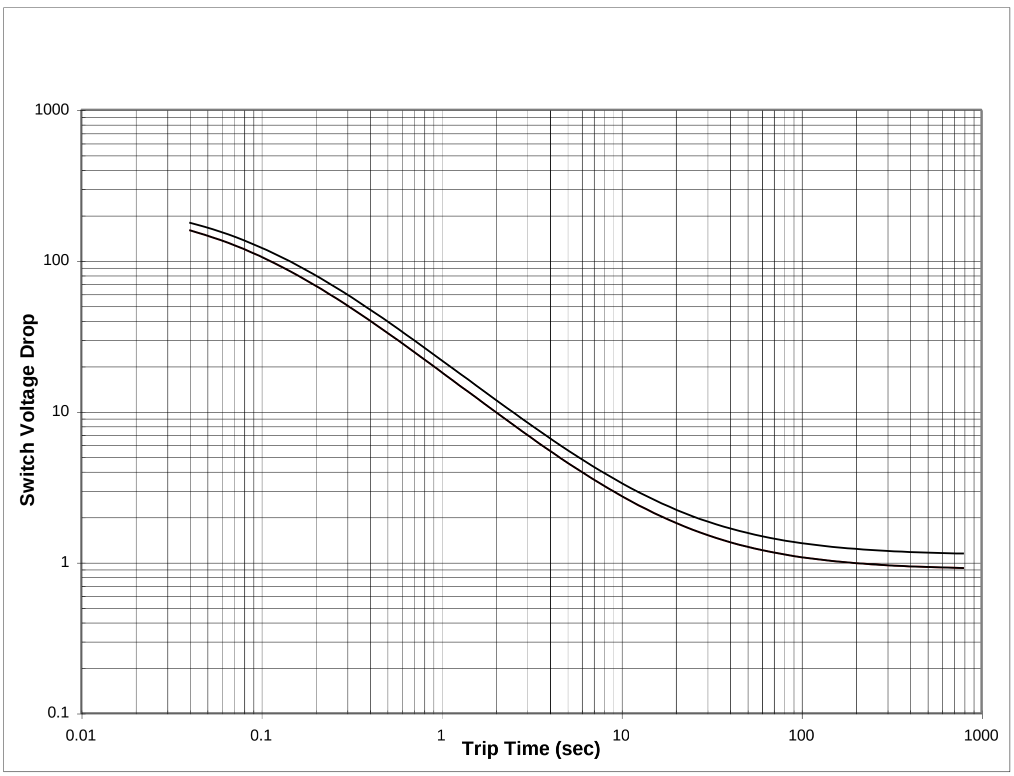


FIGURE 74 FCF EPCU TRIP CHARACTERISTICS CURVE

6.1.1.3 FCF Universal Mounting Location Air-Cooling Interface

N/A

6.1.1.4 FCF Universal Mounting Location Latch Handle Provisions

N/A

6.1.2 Principal Investigator Location

6.1.2.1 Principal Investigator Location Connector Interfaces

The payload components shall be compatible with the PIL pin interfaces for PIL1A, PIL1B, PIL1C and PIL2 provided in TABLE 32 , TABLE 33 , TABLE 34 and TABLE 35 respectively.

TABLE 32 PIL CONNECTOR PIL1 PINOUTS (BAY A)

Pin #	Signal	To Connector	Connector	To Pin #
1	Ethernet Transmit Data +	JOPB3	FCF I/O Processor Connector 1	47
2	Ethernet Transmit Data -	JOPB3	FCF I/O Processor Connector 1	48
3	Ethernet Receive Data +	JOPB3	FCF I/O Processor Connector 1	49
4	Ethernet Receive Data -	JOPB3	FCF I/O Processor Connector 1	50
5	Sync 1	Terminal Block		
6	Sync 1 RTN	Terminal Block		
7	Redundant Sync 1	Terminal Block		
8	Redundant Sync 1 RTN	Terminal Block		
9	CAN Bus +	Terminal Block		
10	CAN Bus -	Terminal Block		
11	CAN Bus +	Terminal Block		
12	CAN Bus -	Terminal Block		
13	PI Video 1+	JOPB3	FCF I/O Processor Connector 1	75
14	PI Video 1-	JOPB3	FCF I/O Processor Connector 1	76
15	PI Video 2+	JOPB3	FCF I/O Processor Connector 1	83
16	PI Video 2-	JOPB3	FCF I/O Processor Connector 1	84
17	PI Video 3+	JOPB3	FCF I/O Processor Connector 1	85
18	PI Video 3-	JOPB3	FCF I/O Processor Connector 1	93
19	PI Video 4+	JOPB3	FCF I/O Processor Connector 1	92
20	PI Video 4-	JOPB3	FCF I/O Processor Connector 1	100
23	Redundant CAN Bus +	Terminal Block		
24	Redundant CAN Bus -	Terminal Block		
25	Redundant CAN Bus +	Terminal Block		
39	Redundant CAN Bus -	Terminal Block		
21, 22	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	5, 6
26, 27	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	7, 14
28, 29	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	8, 9

Pin #	Signal	To Connector	Connector	To Pin #
30, 31	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	15, 24
32, 33	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	10, 11
34, 35	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	12, 13
36, 37	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	16, 17
38,5 2	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	18, 19
40, 41	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	20, 21
42, 43	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	22, 23
44, 45	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	25, 26
46, 47	TW/SHLD PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	27, 28
48, 49	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	29, 30
50, 51	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	31, 32
53, 54	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	33, 34
55, 56	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	35, 36
57, 58	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	37, 38
59, 60	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	39, 40
61, 62	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	41, 42
63, 64	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	43, 44
65, 66	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	45, 55
67, 68	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	46, 47
69, 70	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	48, 49
71, 72	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	50, 51
73, 74	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	52, 53
75, 76	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	54, 65
77,78	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	56, 57
79, 93	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	58, 59

Pin #	Signal	To Connector	Connector	To Pin #
80, 81	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	60, 61
82, 83	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	62, 63
84, 85	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	64, 75
86, 87	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	66, 76
88, 89	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	67, 68
90, 91	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	69, 70
92, 106	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	71, 72
94, 95	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	73, 74
96, 97	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	77, 78
98, 99	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	79, 80
100, 101	TW PR No. 22 AWG PI Configurable	JCTC5	IRR PI Connector	81, 82
102	PI O2 SENSOR 1 A/D	JFCU4	FOMA Control Unit	63
103	PI O2 SENSOR 1 A/D RETURN	JFCU4	FOMA Control Unit	64
104	PI O2 SENSOR 2 A/D	JFCU4	FOMA Control Unit	66
105	PI O2 SENSOR 2 A/D RETURN	JFCU4	FOMA Control Unit	67

Note: Shields for all cables in this table are connected to the Optics Bench at both ends.

TABLE 33 PIL CONNECTOR PIL1 PINOUTS (BAY B)

Pin #	Signal	To Connector	Connector	To Pin #
1, 2	TW/SHLD PR No. 22AWG PI Configurable	JCTC8	IRR PI Connector	1, 2
3, 4	TW/SHLD PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	3, 4
5, 6	39 TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	5, 6
7, 8	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	7, 14
9, 10	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	8, 9
11, 12	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	10, 11
13, 14	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	12, 13
15, 16	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	15, 24
17, 18	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	16, 17
19, 20	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	18, 19
21, 22	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	20, 21
23, 24	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	22, 23
25, 39	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	25, 26
26, 27	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	27, 28
28, 29	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	29, 30
30, 31	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	31, 32
32, 33	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	33, 34
34, 35	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	35, 36
36, 37	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	37, 38
38, 52	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	39, 40
40, 41	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	41, 42
42, 43	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	43, 44
44, 45	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	45, 55
46, 47	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	46, 47
48, 49	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	48, 49
50, 51	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	50, 51
53, 54	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	52, 53
55, 56	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	54, 65
57, 58	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	56, 57
59, 60	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	58, 59
61, 62	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	60, 61
63, 64	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	62, 63
65, 66	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	64, 75
67, 68	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	66, 76
69, 70	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	67, 68
71, 72	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	69, 70
73, 74	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	71, 72
75, 76	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	73, 74

Pin #	Signal	To Connector	Connector	To Pin #
77, 78	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	77, 78
79, 93	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	79, 80
80, 94	TW PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	81, 82
81, 82	1 TW/SHLD PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	83, 84
95	81-82 SHLD			
84, 85	1 TW/SHLD PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	85 ,93
98	84-85 SHLD			
87, 88	1 TW/SHLD PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	86, 87
101	87-88 SHLD			
90, 91	1 TW/SHLD PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	88, 89
104	90-91 SHLD			
96, 97	1 TW/SHLD PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	90, 91
83	96-97 SHLD			
99, 100	1 TW/SHLD PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	92, 100
86	99-100 SHLD			
102, 103	1 TW/SHLD PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	94, 95
89	102-103 SHLD			
105, 106	1 TW/SHLD PR No. 22 AWG PI Configurable	JCTC8	IRR PI Connector	96, 97
92	105-106 SHLD			

Note: Shields for all cables in this table are connected to the Optics Bench at both ends with the exception of shields terminated at pins 83, 86, 89, 92, 95, 98, 101, and 104. The shields on these wire pairs are floated at the other end.

TABLE 34 PIL CONNECTOR PIL1 PINOUTS (BAY C)

Pin #	Signal	To Connector	Connector	To Pin #
1, 2	TW PR NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	A, W
3, 4	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	B, C
5, 6	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	D, Y
7, 8	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	E, Z
9, 19	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	F, a
10, 11	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	G,b
12, 13	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	X, r
14, 15	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	S, t

Pin #	Signal	To Connector	Connector	To Pin #
16, 17	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	H, c
18, 28	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	Q, CC
20, 21	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	u, DD
22, 23	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	J, d
24, 25	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	V, p
26, 27	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	BB, HH
29, 30	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	EE, v
31, 32	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	U, n
33, 34	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	AA, GG
35, 36	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	FF, w
39, 40	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	T, m
41, 42	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	z, y
43, 44	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	X, g
45, 46	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	L, M
48, 49	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	N, h
50, 51	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	P, I
52, 53	NO. 20 AWG PI Configurable	JCTC6	IRR PI Connector	R, j
37, 38	TW/SHLD PR No. 20 AWG PI Configurable	JCTC6	IRR PI Connector	K, f
47	37,38 SHLD			
54, 55	TW/SHLD PR No. 20 AWG PI Configurable	JCTC6	IRR PI Connector	S, k
56	54,55 SHLD			
57	Structure GND 1			

Note: Shields for all cables in this table are connected to the Optics Bench at both ends with the exception of shields terminated at pins 47 and 56. The shields on those wire pairs are floated at the other end.

TABLE 35 PIL CONNECTOR PIL2 PINOUTS

Pin #	Signal	To Connector	Connector	To Pin #
1	PI COAX 1	JCTC7	IRR PI Connector	A
2	PI COAX 2	JCTC7	IRR PI Connector	B
3	1/C NO. 16 AWG PI Configurable	JCTC7	IRR PI Connector	C
4	1/C NO. 16 AWG PI Configurable	JCTC7	IRR PI Connector	D
5	1/C NO. 16 AWG PI Configurable	JCTC7	IRR PI Connector	E
6	1/C NO. 16 AWG PI Configurable	JCTC7	IRR PI Connector	F
7	+28V 8A’	JOPB2	Power 2	J
8	+28V 8A" Return	JOPB2	Power 2	K
9	+28V 8A'	JOPB2	Power 2	L
10	+28V 8A" Return	JOPB2	Power 2	M
11	8A Chamber IN	JOPB2	Power 2	N
12	8A Chamber IN Return	JOPB2	Power 2	P

Pin #	Signal	To Connector	Connector	To Pin #
14	8A Chamber IN	JOPB2	Power 2	R
15	8A Chamber IN Return	JOPB2	Power 2	S
16	1/C NO. 16 AWG PI Configurable	JCTC7	IRR PI Connector	G
17	1/C NO. 16 AWG PI Configurable	JCTC7	IRR PI Connector	H
18	8A Chamber OUT	JCTC7	IRR PI Connector	J
19	8A Chamber OUT Return	JCTC7	IRR PI Connector	K
20	8A Chamber OUT	JCTC7	IRR PI Connector	L
21	8A Chamber OUT Return	JCTC7	IRR PI Connector	M
22	120V IN 1	JCTC7	IRR PI Connector	N
23	120V Return 1	JCTC7	IRR PI Connector	P
24	120V IN 2	JCTC7	IRR PI Connector	R
25	120V Return 2	JCTC7	IRR PI Connector	S
26	Structure GND 2	GND Screw 2		

6.1.2.2 Principal Investigator Location Sync Bus

Payload components shall be compatible with the Sync Bus as defined for UML-mounted payload components in section 6.1.1.2.1 of this document.

6.1.2.3 Principal Investigator Location Analog Video

Payload components shall be compatible with the analog video as defined for UML-mounted payload components in section 6.1.1.2.2 of this document.

6.1.2.4 Principal Investigator Location CAN Bus

Payload components shall be compatible with the CAN Bus as defined for UML-mounted payload components in section 6.1.1.2.3 of this document.

6.1.2.5 Principal Investigator Location Location Address

Payload components that interface to the PIL via the CAN Bus or Ethernet shall use a virtual address of 48.

6.1.2.6 Principal Investigator Location Ethernet

Payload components shall be compatible with the Ethernet as defined for UML-mounted payload components in section 6.1.1.2.5 of this document.

6.1.2.7 Principal Investigator Location Fiber Optic

Payload components that utilize the fiber optic interface shall be compatible with the single mode fiber characteristics provided in TABLE 36 .

TABLE 36 FIBER OPTIC CHARACTERISTICS

Parameter	Single-Mode Value
Core	9 μm
Cladding	125 μm
Numerical Aperture	0.13
Jacket	3 mm Stainless Steel
Operating Wavelength	1300/1550 nm
Cutoff Wavelength	< 1250 nm

6.1.2.8 Principal Investigator Location 28 VDC Power

The PIL supplies two 8 amp, 28 VDC circuits. Payload components shall be compatible with the 28 VDC power characteristics defined in section 6.1.1.2.6 of this document.

6.1.2.8.1 Normal Voltage Levels

Payload components shall be compatible with the requirements defined in section 6.1.1.2.6.1 of this document.

6.1.2.8.2 Non-Normal Output Voltage Levels

Payload components shall be compatible with the requirements defined in section 6.1.1.2.6.2 of this document.

6.1.2.8.3 Payload Load Input Impedance

Payload components shall be compatible with the requirements defined in section 6.1.1.2.6.3 of this document.

6.1.2.8.4 Ripple Voltage Characteristics

Payload components shall be compatible with the requirements defined in section 6.1.1.2.6.4 of this document.

6.1.2.8.5 Reverse Current

Payload components shall be compatible with the requirements defined in section 6.1.1.2.6.5 of this document.

6.1.2.8.6 Wire Derating

Payload components shall be compatible with the requirements defined in section 6.1.1.2.6.6 of this document.

6.1.2.8.7 Power Switches/Controls

Payload components shall be compatible with the requirements defined in section 6.1.1.2.6.7 of this document.

6.1.2.8.8 Overload Protection

Payload components shall be compatible with the requirements defined in section 6.1.1.2.6.8 of this document.

6.1.3 Auxiliary Interface Connectors

Each UML provides 10 wires of undesignated electrical interfaces. These interfaces may be used by the PD to facilitate auxiliary communications between devices. They consist of three twisted pairs of M22759/12-22 wire with an overall shield and two individually shielded twisted pairs of 77 Ohm impedance. The twisted pairs begin on pin 26 and continue sequentially to pin 49 of the UMLs. They are routed to JOPB9 on the front of the Optics Bench. The mechanical details of the connectors are provided in section 3.1.3.1 of this document. Payload components shall be compatible with the pin-outs and materials defined in this section.

6.2 Combustion Chamber

6.2.1 Interface Resource Ring

6.2.1.1 Electrical Feed-Throughs

The Electrical Feed-Through cabling diagram between the Optics Bench and payload is shown in FIGURE 75.

6.2.1.1.1 Connector Interfaces

6.2.1.1.1.1 Electrical Feed-Through JCTC5

The payload shall provide the mating connection from JCTC5 to components located inside the Combustion Chamber. The pin-out configuration for bay 'A' of JPIL1 is provided in TABLE 32 . There is a one-to-one pin correlation between PCTC5 and JCTC5.

6.2.1.1.1.2 Electrical Feed-Through JCTC6

The payload shall provide the mating connection from JCTC6 to components located inside the Combustion Chamber. The pin-out configuration for bay 'C' of JPIL1 is provided in TABLE 34 . There is a one-to-one pin correlation between PCTC6 and JCTC6.

6.2.1.1.1.3 Electrical Feed-Through JCTC7

The payload shall provide the mating connection from JCTC7 to components located inside the Combustion Chamber. In addition to the 28V power, JCTC7 is used to bring two coaxial, 120 VDC power and six custom wires from PIL2 of the PIL to the Combustion Chamber. The pin-out configuration for JPIL2 is provided in TABLE 35 . There is a one-to-one pin correlation between PCTC7 and JCTC7.

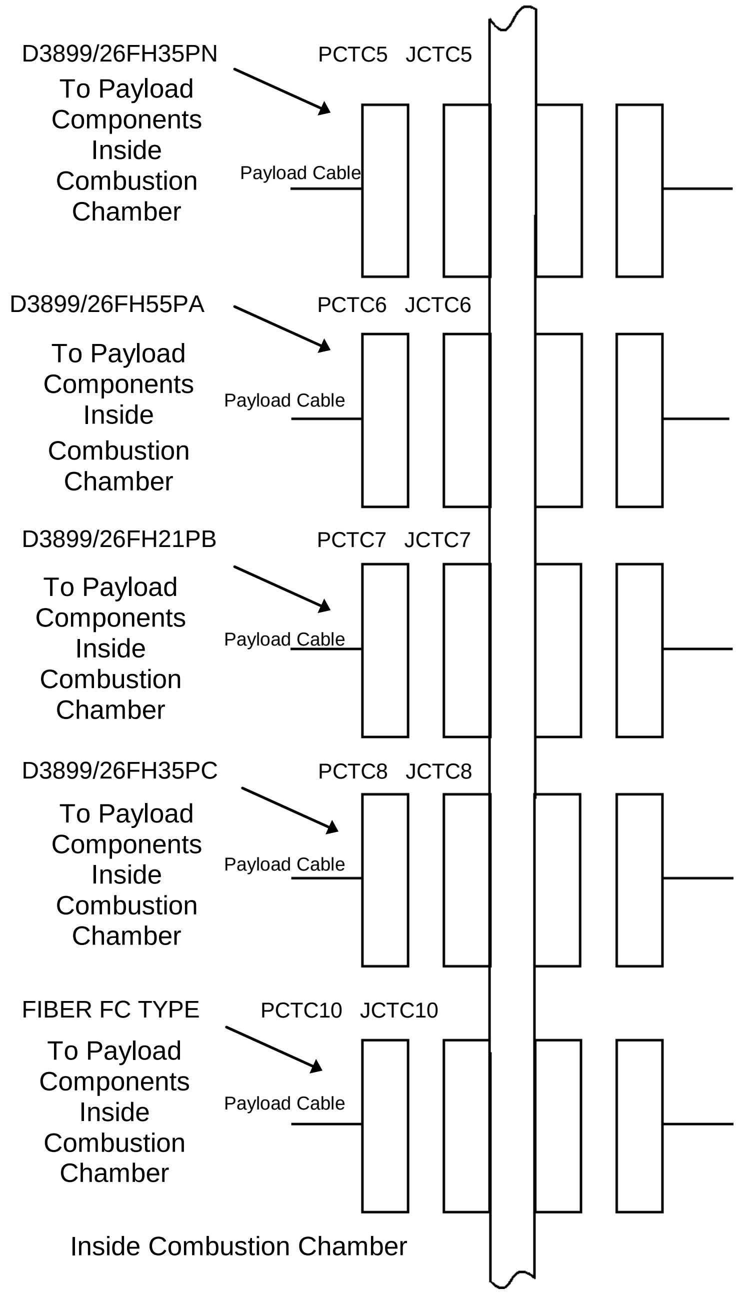


FIGURE 75 INTERFACE RESOURCE RING FEED-THROUGH DIAGRAM

6.2.1.1.1.4 Electrical Feed-Through JCTC8

The payload shall provide the mating connection from JCTC8 to the components located inside the Combustion Chamber. The pin-out configuration for bay ‘B’ of JPIL1 is provided in TABLE 33 . There is a one-to-one pin correlation between PCTC8 and JCTC8.

6.2.1.1.1.5 Fiber Optic Feed-Through JCTC10

The payload shall provide the mating connection from JCTC10 to components located inside the Combustion Chamber. Connector PCTC10 is a FC type that uses a single mode fiber as specified in TABLE 36 . The fiber optic from JCTC10 is routed through the Combustion Chamber and the Optics Bench to an FC type connector on the back of the Optics Bench (JOPB12). From this connector an external connection can be made from the Optics Bench to the PI Avionics Package.

6.3 Fuel/Oxidizer Management Assembly

N/A

6.4 CIR-Provided Diagnostics

6.4.1 FCF Diagnostic Control Module

6.4.1.1 FCF Diagnostic Control Module Kinematic Mount

N/A

6.4.1.2 FCF Diagnostic Control Module Air-Cooling Port

N/A

6.4.1.3 FCF Diagnostic Control Module Electrical Connector

FCF DCM-mounted components will be compatible with the FCF DCM electrical connector part number and the payload-provided mating connector part number as defined in section 3.4.1.3 of this document.

6.4.1.3.1 Motor and Sensor Interface/Camera Control and Power

Payload components shall be compatible with the motor and sensor interface and the camera control and power as provided by the 100-pin connector on the FCF DCM. The payload components connector shall have pin assignments for the motor and sensor interface and the camera control and power connectors that correspond to TABLE 37 and TABLE 38 , respectively.

6.4.1.3.2 Tunable/RGB Filter

N/A

TABLE 37 MOTOR AND SENSOR INTERFACE

Pin #	Description		Pin #	Description
1	Servo Motor 0P		29	Servo 0 Encoder ChA
2	Servo Motor 0N		30	Servo 0 Encoder ChB
3	Stepper Motor 0A		31	+ 5V
4	Stepper Motor 0B		32	Ground
5	Stepper Motor 0C		33	Pos Limit Sensor 1
6	Stepper Motor 0D		34	Neg Limit Sensor 1
7	Servo Motor 1P		35	Servo 1 Encoder ChA
8	Servo Motor 1N		36	Servo 1 Encoder ChB
9	Stepper Motor 1A		37	+ 5V
10	Stepper Motor 1B		38	Ground
11	Stepper Motor 1C		39	Pos Limit Sensor 2
12	Stepper Motor 1D		40	Neg Limit Sensor 2
13	Servo Motor 2P		41	Servo 2 Encoder ChA
14	Servo Motor 2N		42	Servo 2 Encoder ChB
15	Stepper Motor 2A		43	+ 5V
16	Stepper Motor 2B		44	Ground
17	Stepper Motor 2C		45	Pos Limit Sensor 3
18	Stepper Motor 2D		46	Neg Limit Sensor 3
19	Servo Motor 3P		47	Servo 3 Encoder ChA
20	Servo Motor 3N		48	Servo 3 Encoder ChB
21	Stepper Motor 3A		49	+ 5V
22	Stepper Motor 3B		50	Ground
23	Stepper Motor 3C		52	Home Sensor 0
24	Stepper Motor 3D		59	Home Sensor 1
27	Pos Limit Sensor 0		64	Home Sensor 2
28	Neg Limit Sensor 0		70	Home Sensor 3

TABLE 38 CAMERA CONTROL AND POWER

Pin #	Description
53	DC Chassis Ground
54	Camera Power Good
55	Common
56	Camera Power Enable
58	Camera Power Temperature Sense
60	Camera Temperature Sense
61	Camera Temp Sense Return
62	Sync In Ground
63	Sync In
76, 77, 78	+ 28 VDC to Camera Power Supply
79, 80, 81	28V Return
83	Camera Power Temp Sense Return
84	RS232 Ground
85	RS232 Transmit Data
86	RS232 Receive Data
87	CAN Bus -
88	CAN Bus +
89	Sync Out Ground
90	Sync Out
97	Analog Video +
99	Analog Video -
100	Chassis Ground

Note:
Connections 51, 57, 65, 66, 67, 68, 69, 71, 72, 73, 74, 75, 82, 91, 92, 93, 94, 95, 96, and 98 are connected to chassis ground

6.4.2 CIR High Bit Depth/Multispectral Imaging Package

N/A

6.4.3 CIR High Frame Rate/High Resolution Imaging Package

N/A

6.4.4 CIR Low Light Level Ultraviolet Imaging Package

N/A

6.4.5 CIR Low Light Level Infrared Imaging Package

N/A

6.4.6 CIR Optics Housing Module

6.4.6.1 CIR Optics Housing Module Electrical Connector

The payload-provided mating connector part number for the CIR Optics Housing Module electrical connector is defined in section 3.4.6.4 of this document. The payload component connector shall have pin assignments that are compatible with the pin assignments as provided in TABLE 39 .

TABLE 39 CIR OPTICS HOUSING MODULE ELECTRICAL CONNECTOR

Pin #	Signal Description
1	Servo 0P/Stepper 0 A
2	Servo 0N/Stepper 0 B
3	Lens Assembly Sense
4	Track Mirror Assembly Sense
5	Encoder 0 Channel A/Stepper 0C
6	Encoder 0 Channel B/Stepper 0D
7	No Connect
8	No Connect
9	Position Sensor 0
10	Home Sensor 0
11	Spare 1
12	Servo 1P/Stepper 1A
13	Servo 1N/Stepper 1B
14	No Connect
15	No Connect
16	Encoder 1 Channel A/Stepper 1C
17	Encoder 1 Channel B/Stepper 1D
18	Ground
19	+5 VDC
20	Position Sensor 1
21	Home sensor 1

6.4.7 CIR Illumination Control Module

N/A

6.4.8 FCF Image Processing and Storage Unit

6.4.8.1 FCF Image Processing and Storage Unit Fiber Optic Interface

The FCF IPSU Fiber Optic connector is defined in section 3.4.8.1 of this document. Payload components that utilize the fiber optic interface shall be compatible with the single mode fiber characteristics provided in TABLE 36 .

6.4.9 FCF Image Processing and Storage Unit – Analog

N/A

6.5 120 VDC Power Interface

6.5.1 120 VDC Power Interface Connector

The 120 VDC power connector part number and the payload-provided mating connector part number are defined in section 3.5.1 of this document. The payload component connector shall have pin assignments that are compatible with the pin assignments of the 120 VDC connector as provided in TABLE 40 .

TABLE 40 120 VDC CONNECTOR PINOUTS

Pin #	Signal
A	120 VDC channel 1
B	120 VDC channel 1 return
C	Jumper return
D	120 VDC channel 2
E	120 VDC channel 2 return
F	120 VDC channel 3 return
G	120 VDC channel 3
H	N/C
J	N/C
K	Chassis Ground
L	N/C
M	Parallel Jumper 1
N	Parallel Jumper 2
P	Parallel Jumper 3
R	N/C
S	Initial Position Jumper (for CH 1,2,3)

6.5.2 120 VDC Power Requirements

The 120 VDC power interface is supplied from the ISS electrical power system through three FRPCs in the FCF EPCU. Payload components shall be compatible with the detailed characteristics of the power found in SSP 57000 as provided in TABLE 41 . Fields that are grayed-out indicate that the section is only a title in SSP 57000.

TABLE 41 SSP 57000 120 VDC POWER CHARACTERISTICS

SSP 57000 Section	Title
3.2.1.1	Steady-State Voltage Characteristics
3.2.1.1.1	Interface B
3.2.1.2	Ripple Voltage Characteristics
3.2.1.2.1	Ripple Voltage and Noise
3.2.1.2.2	Ripple Voltage Spectrum
3.2.1.3	Transient Voltages
3.2.1.3.1	Interface B
3.2.1.3.3	Fault Clearing and Protection
3.2.1.3.4	Non-Normal Voltage Range
3.2.2	Electrical Power Interface
3.2.2.3	Compatibility with Soft Start/Stop RPC
3.2.2.4	Surge Current
3.2.2.5	Reverse Current
3.2.2.6	Circuit Protection Devices
3.2.2.6.1	ISS EPS Circuit Protection Characteristics
3.2.2.6.1.1 A	Remote Power Controllers (RPCs)
3.2.2.6.2	EPCE RPC Interface Requirements
3.2.2.6.2.1.1	Payload Trip Ratings
3.2.2.7	EPCE Complex Load Impedances
3.2.2.7.1	Interface B
3.2.3.3	Loss of Power
3.2.4	Electromagnetic Compatibility
3.2.4.1	Electrical Grounding
3.2.4.3	Cable/Wire Design and Control Requirements
3.2.5	Safety Requirements
3.2.5.3	Power Switches/Controls
3.12.9	Crew Safety
3.12.9.1	Electrical Hazards
3.12.9.1.4.5	Automatic Restart Protection

6.6 Nominal Power Consumption

The total nominal power consumption of the payload components, CIR core hardware and CIR configurable hardware is 2,000 W, based on the nominal heat rejection capacity of the rack. The nominal power consumption of CIR core hardware and CIR configurable hardware is provided in TABLE 42 .

TABLE 42 CIR HARDWARE POWER CONSUMPTION DATA

CIR Hardware Name	28 VDC (W)	120 VDC (W)
CIR Core Hardware (Full) (1)	583	10
CIR Core Hardware (Downlink)(2)	236	10
CIR Configurable Hardware:	--	--
CIR LLL-UV Imaging Package	49	
CIR LLL-IR Imaging Package	58	
FCF DCM	23	
CIR HiBMS Imaging Package (3)	54	
CIR HFR/HR Imaging Package (3)	54	
CIR ICM	24	
FCF IPSU	110	
FCF IPSU-Analog	110	

Notes:

(1) CIR core hardware includes: FCF I/O Processor, ATCU, EEU, FCF EPCU, FDSS, SSC, SAMS, and WFCA. Cable and FCF EPCU losses included.

(2) Downlink core hardware includes: FCF I/O Processor, FDSS, EEU, SSC, and WFCA. Cable and FCF EPCU losses included.

(3) Includes FCF DCM.

6.6.1 Available Direct Current Power

The maximum Direct Current (DC) power available to payload components is provided in TABLE 43 .

TABLE 43 DC POWER AVAILABLE TO PAYLOAD COMPONENTS

Payload Mounting Location	Available Power (W)
Principal Investigator Location (PIL) (PI Avionics Box)	443 @ 28 VDC
UMLs 3, 5 and 7	443 @ 28 VDC
UMLs 1, 2, 4, 6 and 8	222 @ 28 VDC
PIL (Combustion Chamber, IRR Feed-Throughs)	443 @ 28 VDC
120 VDC Power Interface Connector	1440 @ 120 VDC

6.7 Limitations on Payload Utilization of Electrical Power

6.7.1 Payload Electrical Safety/Hazards

6.7.1.1 Batteries

The payload shall meet the requirements for batteries, as specified in the NSTS 20793, NSTS 1700.7B, and NSTS 1700.7B/ISS Addendum.

6.7.1.2 Safety-Critical Circuits

Safety-critical circuits are any electrical circuits that are used to control a hazard. For payload components with safety-critical circuits, the following applies:

A. The payload safety-critical circuits shall meet the redundancy requirements defined in NSTS 18798, memorandum ET12-90-115
B. The payload safety-critical circuits controlling catastrophic hazards shall meet the margins defined for the conducted susceptibility limits in section 7.1.1.3 of this document and the radiated susceptibility limits specified in SSP 30237, section 3.2.4
C. The Electromagnetic Interference (EMI) Susceptibility safety-critical circuits shall comply with the conducted susceptibility limits specified in section 7.1.7 of this document.

6.7.1.3 FCF Rack Door Switch

When the rack doors are opened, power shall be removed from all payload components that have been identified as hazardous. If desired, PDs may request that certain payload components be powered off when the rack doors are opened.

6.7.2 Emergency Operational Modes

For emergency operational modes, the payload shall be able to sustain a safe condition with permanent loss of power.

6.8 Electrical Connectors

6.8.1 Connector Pins/Sockets

The powered side of a connector pair shall be terminated in sockets rather than pins.

6.8.2 Electrical Connector Mating/Demating

The payload connectors shall not be mated or demated until voltages have been removed from the powered side of the connectors.

7.0 ELECTROMAGNETIC COMPATIBILITY

7.1 Electromagnetic Compatibility

The payload, without the CIR, shall meet the Electromagnetic Compatibility (EMC) requirements of the ISS specified in SSP 57000, section 3.2.4.4.

7.1.1 Emission and Susceptibility Limits

These requirements apply to payload electronic, electrical, electromechanical equipment, and subsystems emissions and susceptibilities.

7.1.1.1 Compatibility

Payload components, designed in accordance with the EMC requirements, shall not malfunction, and performance shall not be degraded during conductive and radiated EMI testing.

7.1.1.2 Conducted Emissions

Payload components shall meet the conducted emission requirements as identified in TABLE 44 .

TABLE 44 CONDUCTED EMISSION REQUIREMENTS

SSP 30237 Section No.	SSP 30237 Section Title
3.2.1.1	CE01, Conducted Emissions
3.2.1.1.1	Applicability
3.2.1.1.2	CE01 Limits
3.2.1.2	CE03, Conducted Emissions
3.2.1.2.1	Applicability
3.2.1.2.2	CE03 Limits
3.2.1.3.	CE07, Conducted Emissions
3.2.1.3.1	Applicability
3.2.1.3.2	CE07 Limits

7.1.1.3 Conducted Susceptibility

Payload components shall meet the conducted susceptibility requirements as identified in TABLE 45 .

TABLE 45 CONDUCTED SUSCEPTIBILITY REQUIREMENTS

SSP 30237 Section No.	SSP 30237 Section Title
3.2.2.1	CS01, Conducted Susceptibility
3.2.2.1.1	Applicability
3.2.2.1.2	CS01 Limits
3.2.2.1.3	Alternate CS01 Limits
3.2.2.2	CS02, Conducted Susceptibility
3.2.2.2.1	Applicability
3.2.2.2.2	CS02 Limits
3.2.2.3.	CS06, Conducted Susceptibility
3.2.2.3.1	Applicability
3.2.2.3.2	CS06 Limits

7.1.1.4 Radiated Emissions

Payload components shall meet the radiated emissions requirements as identified in TABLE 46 .

TABLE 46 RADIATED EMISSIONS REQUIREMENTS

SSP 30237 Section No.	SSP 30237 Section Title
3.2.3.1	RE02, Radiated Emissions
3.2.3.1.1	Applicability
3.2.3.1.2	RE02 Limits
3.2.3.1.2.1	Narrowband Electric Field Emissions

7.1.1.5 Radiated Susceptibility

Payload components shall meet the radiated susceptibility requirements as identified in TABLE 47 .

TABLE 47 RADIATED SUSCEPTIBILITY REQUIREMENTS

SSP 30237 Section No.	SSP 30237 Section Title
3.2.4.1	RS02, Radiated Susceptibility
3.2.4.1.1	Applicability
3.2.4.1.2	RS02 Limits
3.2.4.2	RS03, Radiated Susceptibility
3.2.4.2.1	Applicability
3.2.4.2.2	RS03 Limits

7.1.2 Electrostatic Discharge

Payload components shall comply with the Electrostatic Discharge requirements of SSP 57000, section 3.2.4.5.

7.1.3 Payload-Produced Alternating Current Magnetic Fields

Payload components shall comply with the Alternating Current (AC) magnetic field requirements of SSP 57000, section 3.2.4.6.

7.1.4 Payload-Produced Direct Current Magnetic Fields

Payload components shall comply with the Direct Current (DC) magnetic field requirements of SSP 57000, section 3.2.4.7.

7.1.5 Corona

Payload components shall comply with the corona requirements of SSP 57000, section 3.2.4.8.

7.1.6 Lightning

Payload components shall comply with the lightning requirements of SSP 57000, section 3.2.4.9.

7.1.7 EMI Susceptibility for Safety-Critical Circuits

Payload components shall comply with the safety-critical circuit EMI susceptibility requirements of SSP 57000, section 3.2.4.10.

7.2 Avionics Electrical Compatibility – Shuttle and ISS

7.2.1 Electrical Bonding

The payload-to-CIR electrical bonding interface shall meet the requirements as defined in SSP 30245 and the following sections. Three classes of bonds are applicable to the payload: Classes H, R, and S.

a. Shock Hazard – Class H
Payload components that use CIR power shall have mechanically secure electrical connections to the CIR structure capable of carrying the maximum return fault current that may be produced in the package. The minimum surface area of metal in the bond path shall be four times the equivalent cross-sectional area of copper wiring necessary to carry the fault current. Exposed conducting frames or parts of electrical or electronic equipment shall have a low resistance bond of less than 0.1 ohm to the conducting structure. If the equipment design includes a ground terminal or pin that is internally connected to exposed parts, a ground connection to the terminal or pin shall be provided.

b. Radio Frequency (RF) Bond – Class R
Payload components that contain electrical circuits that generate radio frequencies or circuits that are susceptible to radio frequency interference may require a low impedance path to structure in order to comply with EMC requirements. The bonding methods used in these elements shall result in a DC resistance of less than 2.5 milliohms across each faying surface in the bond path from enclosure to structure and an impedance of less than 100 milliohms up to a frequency of 1 megahertz (MHz).

c. Static Bond – Class S
All conducting items subject to frictional or any other charging mechanism shall have a mechanically secure electrical connection to the payload element structure. The resistance of this connection shall be less than 1 ohm for each joint.

7.2.1.1 Electrical Bonding of Payload Components

Payload components that generate and/or are susceptible to RF interference shall utilize Class R bonding across each faying surface in the bond path. In addition, the metallic shells of all external electrical connectors shall be electrically bonded to the payload components case or the payload components bulkhead mount with a DC resistance of less than 2.5 milliohms across each faying surface.

Wire harness shields external to equipment, that require grounding at the payload components, shall have provisions for grounding the shields to the payload components through the harness connector back shell or for carrying shields through the connector pins.

7.2.1.2 Electrical Bonding of Payload Structures

7.2.1.2.1 Payload-to-CIR Main Bond

Accommodations available within the CIR to provide bonding surfaces/paths for the payload components are detailed below. The JPIL connector on the Optics Bench provides a Class H bond path when the mating contact in the payload component is wired to the payload chassis. The preferred method for RF bonding (Class R) is the mated/faying surface bond between the Optics Bench and the mounting surface of the payload components.

7.2.1.2.1.1 Primary Payload Power Connector Bond

The primary payload current fault bond path shall be through the Optics Bench payload power connector interface, JPIL1. The bond path is accomplished using a single AWG #20 wire located at pin 57 on connector JPIL1-C and a single AWG #16 wire located at pin 26 on connector JPIL2. The pinouts are provided in TABLE 34 and TABLE 35 respectively. The bond resistance shall be 0.1 ohm or less. An additional bond path is provided through the Optics Bench/payload components mating surfaces.

Bonds shall meet the appropriate bond class requirements of section 7.2.1 of this document and the payload shall have a resistance less than or equal to 2.5 milliohms, at each faying surface in the Class R bond path.

7.2.1.2.1.2 Payload-to-CIR Mated Surface Bond

The payload-to-CIR mating surface bond is a removable bond between the mounting surface of the payload components and the Optics Bench. This bond also exists between the payload components and the Combustion Chamber Grounding Interface. The resistance between the mated surfaces of the Optics Bench and the payload components shall be less than or equal to 2.5 milliohms. The resistance between the mated surface of the Combustion Chamber grounding interface and the payload components shall also less than or equal to 2.5 milliohms.

7.2.1.2.1.3 Payload-to-CIR and Fluid Line Bonding

All metallic fluid lines used to connect the payload to the CIR Environmental Control System (ECS) (i.e., filters, gas bottles, etc.) shall meet a Class S bond.

7.3 Power Circuit Isolation and Grounding

The payload-to-CIR Power Circuit Isolation and Grounding shall meet the requirements as defined in SSP 30240 and the following sections.

7.3.1 CIR 28 VDC Primary Power Bus Isolation

All 28 VDC return lines coming from the FCF EPCU are DC isolated from the CIR structure by a minimum of 1 Megohm. Payload components shall not connect the CIR power return line to a secondary power return developed inside a package if the secondary line is referenced to structure at any point. All 28 VDC return lines are connected to structure inside the FCF EPCU.

7.3.2 Direct Current Power Ground Reference

Secondary voltages that are developed using DC/DC converters shall be referenced to structure at a single location. This connection to structure shall implement a Class H bond.

7.3.3 Payload Secondary Power Isolation and Grounding

Where equipment further conditions and isolates electrical power for external package-to-package isolation or external signal-to-signal isolation, each secondary conditioned power reference shall be treated individually in the same manner as in section 7.3.2 of this document.

Signal circuits external to packages with frequency content below 4 MHz shall be balanced and shall be individually isolated from chassis, structure, and payload conditioned power return by a minimum of 6 kilohms (i.e. measured per connection, pin, wire, etc.).

Signal circuits with frequency components equal to or above 4 MHz shall use controlled impedance transmission and reception media such as twisted 72-ohm cable, twin-axial cable, tri-axial cable, or coaxial cable. Circuits using twin-axial cable shall be balanced and referenced to the primary structure at a single point.

7.3.4 Ground Support Equipment Isolation and Grounding

GSE that interfaces with payload components installed in the CIR shall have power returns isolated from the payload structures by a minimum of 1 Megohm, except where differential circuits are used. In the case of differential circuits, each side of the circuit shall be isolated from ground by no less than 6 kilohms. Coaxial cables, with grounding of the signal return to structure, are permitted, provided that the interface with other payloads or systems does not propagate the ground to circuits already referenced to ground at some other point.

7.4 Signal Isolation and Grounding Requirements

Payload components must comply with the isolation and grounding requirements for received and transmitted signals.

7.4.1 Ethernet

Isolation and grounding for received and transmitted signals shall be per IEEE 802.3.

7.4.2 Controller Area Network Bus

Payload components that interface to the Optics Bench CAN Bus shall meet the electrical characteristics, signal isolation and grounding as specified in ISO 11898.

7.4.3 Video

Video signals shall be transmitted using either RG-179 coaxial cable or equivalent for single ended video signals or 77 ohm twisted shielded pair for balanced video signals. Transmitting signal return lines shall be referenced to signal ground.

7.4.4 Shield References

Shields shall not be designed to carry signal return current except in the case of coaxial cables. Cable shields may be connected to the structure using 360° back shells at both ends of the cable. If a back shell is not possible, the shield may be connected to structure using as short a wire as possible.

8.0 COMMAND AND DATA HANDLING INTERFACES

8.1 Flight Software Interfaces

8.1.1 Optics Bench

8.1.1.1 Universal Mounting Locations

A payload sending and/or receiving commands shall meet the requirements in section 8.1.7.4 of this document. A payload sending and/or receiving telemetry shall meet the requirements in section 8.1.7.5 of this document.

8.1.1.1.1 Universal Mounting Location Location Address

A Computer Software Configuration Item (CSCI) that interfaces to a UML connector shall use the location address assignments for that UML as defined in FCF-ICD-0076, section 3.2.1.

Each UML connector provides a 6-bit location address. The eight UML connectors on the CIR have location addresses corresponding to the binary patterns for numbers 33 – 40 as identified in TABLE 31 . In addition, UMLs 3, 5 and 7 each contain a second set of address pins with location identifiers 43, 45, and 47 respectively.

8.1.1.1.2 Universal Mounting Location Sync Bus

N/A

8.1.1.1.3 Universal Mounting Location Analog Video

N/A

8.1.1.1.4 Universal Mounting Location CAN Bus

A CSCI that interfaces with the Optics Bench CAN Bus shall use the software protocol specified in FCF-ICD-0076, section 3.2.3.11. Any CSCI located at a UML that needs to define a CAN identifier shall select from the pool of identifiers assigned to that UML.

The requirements for a payload CSCI sending and/or receiving commands are provided in section 8.1.7.4 of this document. The requirements for a payload CSCI sending and/or receiving telemetry are provided in section 8.1.7.5 of this document.

8.1.1.1.5 Universal Mounting Location Ethernet

A CSCI that interfaces to Ethernet shall use the software protocol specified in FCF-ICD-0076, section 3.2.4.

Each UML connector provides an interface to the FCF I/O Processor Ethernet Switch.

8.1.1.2 Principal Investigator Location

A payload sending and/or receiving commands shall meet the requirements in section 8.1.7.4 of this document. A payload sending and/or receiving telemetry shall meet the requirements in section 8.1.7.5 of this document.

8.1.1.2.1 Principal Investigator Location Location Address

A CSCI that interfaces to the PIL shall use the FCF addressing scheme defined in FCF-ICD-0076, section 3.2.1. Specifically, it shall assume a “virtual” address of 48 as shown in FCF-ICD-0076, section 3.2.1.4.

8.1.1.2.2 Principal Investigator Location Sync Bus

N/A

8.1.1.2.3 Principal Investigator Location Analog Video

N/A

8.1.1.2.4 Principal Investigator Location CAN Bus

A CSCI that interfaces with the Optics Bench CAN Bus shall use the software protocol as defined in FCF-ICD-0076, section 3.2.3.11. Any CSCI located at the PIL that needs to define a CAN identifier shall select from the pool of identifiers assigned to the PIL.

8.1.1.2.5 Principal Investigator Location Ethernet

A CSCI that interfaces to the PIL Ethernet shall use the software protocol as defined in FCF-ICD-0076, section 3.2.4.

8.1.1.3 Auxiliary Interface Connectors

N/A

8.1.2 Combustion Chamber

8.1.2.1 Interface Resource Ring

N/A

8.1.3 Fuel/Oxidizer Management Assembly

A CSCI cannot be located at the FOMA Control Unit connector because the control of the FOMA has a number of safety-related issues. In addition, as shown in TABLE 48 , a CSCI cannot command the FOMA hardware, either directly or by routing a command through the FCF I/O Processor. All FOMA control commands will be issued by the FOMA Control Unit, FCF I/O Processor, SSC, or the ground segment.

If a CSCI needs to protect hardware based on telemetry data (e.g., close a CIR-provided valve because a pressure was too high) the off-nominal limits of the telemetry need to be documented in FCF-LST-0874, including which processor (e.g., FCF I/O

Processor MP) is to take what action when the signal is off-nominal.

8.1.4 CIR-Provided Diagnostics

8.1.4.1 FCF Diagnostic Control Module

A CSCI shall route Diagnostic Package commands to the FCF DCM via the FCF IPSU. The FCF DCM is directly controlled by an FCF IPSU. All commands routed to the FCF DCM via the FCF IPSU are documented in FCF-ICD-0076, Appendix C.1.1.

8.1.4.1.1 FCF Diagnostic Control Module CAN Bus

A CSCI shall not directly command the FCF DCM via the CAN Bus.

8.1.4.1.2 FCF Diagnostic Control Module Ethernet

N/A

8.1.4.1.3 FCF Diagnostic Control Module RS-232

A CSCI that interfaces to a FCF DCM's RS-232 interface shall implement the command and telemetry protocol described in FCF-ICD-0076, Appendix D.2.

The RS-232 interface in the FCF DCM is a command/response implementation where the FCF DCM initiates the commands and/or telemetry requests. The FCF DCM does not accept any unsolicited communications over the serial port. As such, the FCF DCM cannot communicate with a CSCI via the RS-232 interface until the payload's command set has been implemented in the FCF DCM.

8.1.4.2 CIR High Bit Depth/Multispectral Imaging Package

The FCF DCM provides the interface between the Optics Bench CAN Bus and the various components of the CIR HiBMS Imaging Package. All CIR HiBMS Imaging Package commands routed to the FCF DCM via the FCF IPSU are documented in FCF-ICD-0076, Appendix C.1.1.

8.1.4.3 CIR High Frame Rate/High Resolution Imaging Package

The FCF DCM provides the interface between the Optics Bench CAN Bus and the components of the CIR HFR/HR Imaging Package. All CIR HFR/HR Imaging Package commands routed to the FCF DCM via the FCF IPSU are documented in FCF-ICD-0076, Appendix C.1.1.

8.1.4.4 CIR Low Light Level Ultraviolet Imaging Package

The FCF DCM provides the interface between the Optics Bench CAN Bus and the various components of the CIR LLL-UV Imaging Package. All CIR LLL-UV Imaging Package commands routed to the FCF DCM via the FCF IPSU are documented in FCF-ICD-0076, Appendix C.1.1.

8.1.4.5 CIR Low Light Level Infrared Imaging Package

The FCF DCM provides the interface between the Optics Bench CAN Bus and the various components of the CIR LLL-IR Imaging Package. All CIR LLL-IR Imaging Package commands routed to the FCF DCM via the FCF IPSU are documented in FCF-ICD-0076, Appendix C.1.1.

8.1.4.6 CIR Illumination Control Module

A CSCI shall route CIR Illumination Control Module (ICM) commands to the CIR ICM via the FCF IPSU.

The CIR ICM is directly controlled by an FCF IPSU. All commands routed to the CIR ICM via the FCF IPSU are documented in FCF-ICD-0076, Appendix C.1.1.

8.1.4.6.1 CIR Illumination Control Module CAN Bus

A CSCI shall not directly command the CIR ICM via the CAN Bus.

8.1.4.6.2 CIR Illumination Control Module Ethernet

N/A

8.1.4.6.3 CIR Illumination Control Module RS-232

A CSCI that interfaces to a CIR ICM's RS-232 interface shall implement the command and telemetry protocol described in FCF-ICD-0076, Appendix D.2.

The RS-232 interface in the CIR ICM is a command/response implementation where the CIR ICM initiates the commands and/or telemetry requests. The CIR ICM does not accept any unsolicited communications over the serial port.

8.1.4.7 FCF Image Processing and Storage Unit

The PD software interface to the FCF IPSU is documented in MRD-MAN-0133, section 4 and version FCF-IPSU-MP-04-01. The kernel settings are listed in APPENDIX D of this document.

The FCF IPSU supports the Serial Data Link interface from the digital cameras in the CIR. The FCF IPSU is capable of running PD software to process raw imaging and sensor data, to extract quantitative data and information of interest, and to perform data compression.

PD software running on the FCF IPSU may take advantage of the following features:

- The FCF IPSU application contains software that starts the CSCI.
- The CSCI has a section of commands allocated for payload application specific commands. The FCF IPSU application does not know how to handle payload commands, so it allows the payload application to be called for any of its commands.
- The CSCI has a buffer allocated for payload application specific telemetry. The FCF IPSU application does not know the definition of the payload telemetry, so it allows

the payload application to fill its portion of the telemetry packet.
- The CSCI application is allocated 256 bytes for telemetry (byte divisions are listed in FCF-ICD-0076).
- The CSCI has an interface to the many events and parameters of the FCF IPSU.

8.1.4.8 FCF Image Processing and Storage Unit – Analog

The PD software interface to the FCF IPSU-Analog is documented in MRD-MAN-0133 section 4 and version FCF-IPSU-MP-04-01. The kernel settings are listed in APPENDIX D of this document.

The FCF IPSU-Analog is identical to the FCF IPSU described in section 8.1.4.7 of this document, with the exception that the FCF IPSU-Analog supports an analog frame grabber rather than a digital serial data link.

8.1.5 FCF Mass Data Storage Unit

<TBD 08-01>

8.1.6 120 VDC Power Interface

N/A

8.1.7 Additional Flight Software Interfaces

The additional flight software interfaces consist of requirements that do not apply to one specific hardware interface, or are unrelated to hardware in general.

8.1.7.1 Common Base Class Software Interface

The PD software interface to the Common Base Classes is documented in detail in MRD-MAN-0133, section 3.0 and version FCF-CBC-PEP-04-01.

The FCF Common Base Classes consist of two segments, referred to as the FCF Common Base Classes Application Layer, and the FCF Common Base Classes Library Layer. The FCF Common Base Classes Library Layer provides reusable code shared across packages. The FCF Common Base Classes Application Layer provides a generalized application framework for all FCF and FCF-specific PD package software.

The common base classes are intended to aid the PD in the following manner:

- Ensure the proper formatting and transmission of command and telemetry packets used for communication between a payload CSCI and a CIR CSCI, the ground, or the SSC.
- Implement persistent storage of configuration-related data in a single-fault tolerant, and accessible manner.
- Implement data acquisition, processing, and calculations with timestamps requiring microsecond accuracy.
- Provide a ranked hierarchy of developer-supplied software elements (classes)

capable of handling FCF commands.

- Provide the automation and/or simplification of tasks required to operate as a package in the FCF. These tasks include, but are not limited to, the reporting of telemetry data and the routing of commands to responsible package-layer sub-components.

8.1.7.2 Data Management Software Interface

8.1.7.2.1 FCF Input/Output Processor File Structure

A CSCI shall restrict its file storage on the FCF I/O Processor to the following path:

<IOP drive>/PI/<experiment name>/…

<IOP drive> refers to one of the FCF I/O Processor's two hard drives, /sd0 or /sd1. A CSCI may use either /sd0 or /sd1 for file storage. **<experiment name>** is determined through a configuration file entry.

The PD may create a custom directory structure below this point.

8.1.7.2.2 Data Management Commands

Forward commands to the FCF I/O Processor are limited to 84 bytes of user data. The FCF I/O Processor supports the following data management commands:

cd Used to get to a relative path on the FCF I/O Processor hard drive. One or more cd commands could reach a subdirectory of interest.

get file Used to retrieve a file (or files) from the current directory, or from the directory path specified in the command. The complete path name is limited to 80 characters. Wild cards are allowed. The get file command will download the specified file from the relative path, where the 80 characters can be used for long file names, or for shorter relative path names.

copy file Used to copy one or more files from the current directory to a specified path on an FCF I/O Processor hard drive. Wild cards are allowed.

move file Used to move one or more files from the current directory to a specified path on an FCF I/O Processor hard drive. Wild cards are allowed. The move operation includes the deletion of the source files.

delete file Used to remove one or more files from the current directory. Wild cards are allowed.

<TBD 08-02>

8.1.7.2.3 Data Summary

The flight segment and ground segment both have the requirement of being able to provide a summary of all data stored in the Flight Segment, including identification of each measurement, time stamp/duration of data for each measurement, and file sizes.

Any files created by a CSCI and stored on an FCF component shall include a header that clearly identifies the contents of the file. **<TBD 08-03>**

For image files, the FCF IPSU/FCF IPSU-Analog maintains a separate summary file for each test point, and includes information such as the number of images captured during the test point.

8.1.7.3 Required States

In order for a CSCI to interface to the CIR, the CSCI shall implement the applicable rack-level states identified in the following sections. These states are further defined in FCF-ICD-0076, section A.2.3.1.3.

8.1.7.3.1 Initialization State

The Initialization State is entered when the payload component is first powered. The detailed implementation of the initialization state is package-specific.

8.1.7.3.2 Operational State

The Operational State is entered when the CSCI successfully completes its initialization. The CSCI is considered operational while functioning nominally and not preparing for shutdown. The CSCI may define package-level sub-states within the operational states, but one of those states shall be an Idle State where the experiment is suspended and waiting for further commands.

8.1.7.3.2.1 Idle State

The CSCI shall support a forward command to put the system into the Idle State. If a CIR package goes into its Off-Nominal State, the FCF I/O Processor will command all other packages to their Idle State, and await further instructions from the ground segment.

8.1.7.3.3 Off-Nominal State

The Off-Nominal State is entered when a significant error occurs during system initialization, or during the nominal operation of the FOMA Control Unit Main Processor (MP) CSCI.

8.1.7.3.4 Safed State

The Safed State is entered in preparation for shutting down the payload component. In addition, if a payload component operates as a sub-package (or child) to another payload package (or parent), the parent is responsible for commanding the child to its Safed State.

8.1.7.4 Command Requirements

All commands sent from a CSCI shall follow the nominal command paths as described in TABLE 48 .

The command requirements describe the nominal communication source/destination paths available to a PD in the CIR. The nominal communication paths fall into three categories: routed, direct, and not available.

TABLE 48 NOMINAL COMMAND PATHS

		Destination													
		FCF I/O Processor MP	FCF I/O Processor CBP	FCF I/O Processor VSP	FCF I/O Processor HRDL	ECS	FCF EPCU	FCF IPSU MP	FCF IPSU CBP	FOMA Control Unit MP	FOMA Control Unit CBP	FCF DCM MP	CIR ICM MP	PD Software (PIL)	PD Software (UML)
Source	FCF I/O Processor MP		D	D	D	D	D	D	D	D	D	R	R	D	D
	FCF IPSU MP	D	X	X	X	X	R		D	X	X	D	D	X	X
	FOMA Control Unit MP	D	X	X	X	X	X	X	X		D	X	X	X	X
	SSC	D	R	R	R	R	R	R	R	R	R	R	R	R	R
	Ground	D	R	R	R	R	R	R	R	R	R	R	R	R	R
	PD Software (PIL)	D	X	X	X	X	X	R	X	X	X	R	R		D
	PD Software (UML)	D	X	X	X	X	X	R	X	X	X	R	R	D	

Note: D = Direct; R = Routed; X = Not Available

8.1.7.4.1 Routed Commands

Routed Commands can only be sent to a destination package by routing them through another package.

For example, a CSCI located at the PIL needs to set the frame rate of the camera in the CIR HFR/HR Imaging Package, but the payload cannot directly command a CIR component. Since CIR diagnostic packages are typically controlled by an FCF IPSU, the payload would route a command through the FCF I/O Processor to the FCF IPSU. The FCF IPSU in turn would command the CIR HFR/HR Imaging Package to change its frame rate to the requested setting.

This routing scheme allows the CIR to preserve any parent/child relationships that exist, while providing a payload CSCI with the flexibility to inject commands into the system. The FCF IPSU is a parent to the FCF DCM in the CIR HFR/HR Imaging Package, and understands all of the protocols for sending commands. The FCF I/O Processor is effectively the parent for the entire rack and understands the protocols for commanding all of the CIR components. As such, a payload can command a CIR component with minimal understanding of the CIR architecture.

8.1.7.4.2 Direct Commands

Direct Commands are sent from a source package directly to a destination package, where the destination package takes any actions associated with the command. These commands may be sent over Ethernet and/or CAN Bus.

A payload may send commands directly to the FCF I/O Processor (via Ethernet, since the FCF I/O Processor has not implemented any CAN Bus commands available to a payload CSCI). A CSCI may also send commands directly to another CSCI via Ethernet or CAN Bus, but it shall follow the requirements imposed on that communication path as shown in TABLE 48 .

For example, a CSCI residing at the PIL may send a command via CAN Bus directly to a CSCI at a UML connector, as shown in TABLE 48 .

8.1.7.4.3 Not Available Commands

A particular command path is defined as a Not Available Command if there is no physical interface for a given source/destination path, or if the destination component does not allow a particular source to command it.

Although a CSCI can send direct commands to the FCF I/O Processor, and the FCF I/O Processor can send direct or routed commands to most CIR components, a number of those command paths are identified as Not Available because that CIR component will not accept commands from a payload CSCI.

For example, a payload could attempt to send a command to the FCF I/O Processor MP to be routed to the FOMA Control Unit CAN Bus Processor (CBP). Since the FOMA Control Unit CBP has not identified a need to make its commands available to a CSCI, the FCF I/O Processor would reject the command as shown in TABLE 48 .

8.1.7.5 Telemetry Requirements

All payload flight segment components shall monitor and provide telemetry for any data elements that describe the H&S of their package. That data is collected by the FCF I/O Processor, stored on its hard drives, and transferred to the ground and/or the SSC.

While collecting H&S data, the CSCI shall be capable of looking for and reacting to off-nominal conditions. Additionally, the PD may have the FCF I/O Processor monitor one or more of the data elements that make up a payload's telemetry packet. The PD is responsible for identifying which data elements are important for describing the health of the CSCI, and what action to take based on the off-nominal condition.

All PI avionics will go through a signal list evaluation with FCF personnel. The signal list evaluation will include the identification of H&S data elements. The FCF-LST-0874 is a spreadsheet that includes the signals available to each FCF processor, the nominal ranges for each signal, and the off-nominal actions based on those signals.
A CSCI may use Ethernet or CAN Bus for reporting the H&S of the payload component, but Ethernet is the preferred method unless there is a compelling reason to use CAN Bus. In addition, if a payload component operates as a sub-package (or child) to another payload package (or parent), the parent is responsible for collecting telemetry from the child.

All telemetry packets sent by a CSCI to the FCF I/O Processor via Ethernet shall adhere to the FCF Telemetry Protocol described in FCF-ICD-0076, appendix A.2. Telemetry packets sent to the FCF I/O Processor via CAN Bus do not need to follow a specific pattern, but must be well documented with any FCF I/O Processor monitored data elements clearly defined.

All telemetry packet headers shall contain the current state of the CSCI as defined in section 8.1.7.3 of this document.

8.1.7.6 Error Handling Requirements

A CSCI shall include an off-nominal state as described in section 8.1.7.3.3 of this document. The CSCI determines what constitutes an off-nominal situation. There may be a case where an error does not necessarily cause a package to enter the Off-Nominal State. Some packages have a "degraded" sub-state that is still part of the Operational State.

For example, a CSCI might lose a transducer signal, but not want to enter the Off-Nominal State and subsequently stop the current experiment. It would rather continue the experiment while notifying the ground via telemetry that there was an anomaly.

In general, there should be no expectation to "recover" from an error condition and continue after some period of time, especially with any kind of serious error condition. If a situation arises that puts a system into its off-nominal state, it is the responsibility of the ground or crew to clear the error condition and allow the rack to return to nominal operations.

8.1.7.7 Internet Protocol Address Assignments

The assignment of Internet Protocol (IP) addresses in the CIR follows the same scheme as the assignment of CAN identifiers. The IP assignments for each connector address are listed in FCF-ICD-0076, section 3.2.3. If a CSCI can determine its connector location, it shall use the IP address assigned to that connector.

Any package that cannot determine its location shall obtain its IP address from an experiment-specific configuration file.

8.2 Ground Software Interfaces

8.2.1 Data Formats

The FCF System transfers data from the ISS to ground. Data is transmitted to the ground through telemetry packets either during an ongoing experiment or during pre- or post-experiment operations.

8.2.1.1 Command Formats

Commands shall be transmitted to the FCF on-orbit using the Telescience Resource Kit (TReK) workstation to interface with the Payload Operations Integration Center (POIC) at Marshall Space Flight Center (MSFC).

PDs shall command the payload components using the TReK to relay commands through the FCF Operations Cadre to the POIC, from which the commands will be transmitted to the FCF as specified in SSP 50304, section 4.2.3. Operational commanding scenarios are found in FCF-PLN-0875, section 8.3.6. TReK commands are formatted according to SSP 50305, volume 2.

8.2.1.2 Telemetry Formats

Telemetry types originating at FCF on-orbit include H&S and Engineering and Science (ES) types. H&S telemetry is transmitted over the ISS 1553 network and sent to ground over the S-band downlink where it is routed through the Payload Data Services System (PDSS) at MSFC. ES telemetry is transmitted nominally over the Medium Rate Data Link (MRDL) or High Rate Data Link (HRDL) on-orbit and downlinked over Ku-band where it is routed through the Enhanced Huntsville Operations Support Center (HOSC) System (EHS) at MSFC. From the PDSS and EHS at MSFC, all relayed telemetry is sent to the GRC TSC over an IP Wide Area Network (WAN) connection in User Datagram Protocol (UDP) packets or, in the case of custom-built packets assembled by the EHS, Transmission Control Protocol (TCP). Details of telemetry encapsulation can be found in the SSP 50305, volumes 1 and 2.

8.2.1.2.1 Health and Status Telemetry

The ISS-to-ground packet format for H&S telemetry is detailed in SSP 50305, Volume 1. The format of the FCF H&S telemetry packet, encapsulated in the SSP 50305-defined H&S telemetry packet (see SSP 50305, section 8), is defined in FCF-ICD-0076, Appendix A. PDs will be responsible for specifying the format of PI avionics package H&S data encapsulated within SSP 50305-defined H&S packets and for making the FCF Operations Cadre aware of all such formats so that the FCF Operations Cadre may monitor PI Avionics packages during ongoing operations, if necessary.

8.2.1.2.2 Engineering and Science Telemetry

ES telemetry is encapsulated in GSE packets, as defined in SSP 50305, Volume 1. The FCF telemetry data encapsulated in the GSE packet is formatted in accordance with FCF-ICD-0076, Appendix A. Payloads that process GSE packets will coordinate with the FCF Operations Cadre and the TSC staff per FCF-PLN-0875, section 6.0 to have packets relayed to their TReK or GSE workstations.

8.2.1.3 File Formats

Files downlinked from the FCF on-orbit will be reassembled into their on-orbit state by the FCF Operations Cadre, as specified in FCF-PLN-0875, sections 8.0 and 8.3. Once reassembled, the files will be distributed to PDs.

Standard FCF file formats (files not processed by PI Avionics packages) are defined in FCF-DOC-0070 Appendix D and FCF-ICD-0076, Appendix C, section 1.1.

8.2.1.4 Archive Formats

Archives of telemetry data created by the FCF Operations Cadre on-ground include raw telemetry packet data, processed telemetry data, downlinked files, raw uplinked files and command packet data originating at the FCF on-orbit. Archived ground data includes raw telemetry packet data, processed telemetry data, Payload Rack Checkout Unit (PRCU)-originating data, Operations Log Data, and Orbital Replacement Unit (ORU) Log data.

Archived raw telemetry data will be formatted by TReK as packet record files as defined by TREK-USER-003.

Archived data stored using the Telemetry Acquisition and Display System (TADS) will be formatted as specified in TADS-USER-003.

Archived data stored using the Central Data System (CDS) Client API will be formatted precisely as it was input to the CDS.

A PD that stores data to the CDS will be solely responsible for the formatting of the data.

8.2.1.5 Compression Algorithms

The FCF Ground Segment implements no compression algorithms on-ground. Image data compressed using ‘Delta’ compression on-orbit may be decompressed as per FCF-DOC-0070, section 6.7. The FCF Ground Support Personnel (GSP) decompress any ‘Delta’ compressed data before providing that data to recipients. Any other compression algorithms used per FCF-DOC-0070 are standard image formats and are not decompressed prior to PD provision.

8.2.2 Communication Protocols

Communications between the ISS and GSP include voice and data protocols. ISS to ground communications can include video, H&S or ES telemetry. Ground to FCF on-orbit communications can include commanding or file uplink.

8.2.2.1 Commanding

All commanding of the FCF on-orbit is performed through the FCF Operations Cadre, which interfaces directly with the POIC, through which all payload commanding is accomplished. Integration of payloads into the TSC is performed according to FCF-PLN-0875, sections 5.0 through 8.0.

PDs that command shall do so using the TReK API to interface with the FCF Operations Cadre.

8.2.2.2 Telemetry

Telemetry consists of any digital data transmitted from the FCF on-orbit to the FCF Operations Cadre on-ground over the ISS Low Rate Data Link (LRDL), MRDL, or HRDL, as well as digital video data.

8.2.2.2.1 Video Data

Video data downlinked from the FCF on-orbit is routed through NASA systems and delivered to the GRC TSC as analog NTSC signal per SSP 54001, section 2805.01.

8.2.2.2.2 Downlinks

The FCF Operations Cadre uses TADS software to downlink the on-orbit FCF data, in accordance with FCF-PLN-1043, section 6.1.1.2. File downlink protocol is accomplished through the TADS by commands and telemetry receipt as specified in FCF-ICD-0076, Appendix B section 1.1.

8.2.2.2.3 Uplinks

Uplinks of file data are performed by the FCF Operations Cadre according to FCF-PLN-0875, section 8.1.4.2. Uplink and file commands are formatted by the TReK API according to SSP 50305, Volume 2. The TReK API is documented in TREK-USER-0023.

8.2.2.3 Archive Storage and Retrieval

PDs that archive data shall use either the CDS Client API CSCI or the TADS CSCI. The TADS makes use of the CDS Client API CSCI to store data to the CDS Server API, where data is archived. Requirements for the CDS APIs are as specified in FCF-REQ-0767, sections 4.2.1 and 4.2.4.2.

PDs that retrieve archive data from the CDS shall use the TADS, the CDS Client API or the FCF Operations Cadre by request as specified in FCF-PLN-0875, section 8.3.3.7.

8.2.2.4 Web Server

PDs that distribute data to the Internet from the TSC via the External Services Network (ESN) shall do so using the CDS Web Server. Usage of the CDS Web Server requires implementation of dynamic web pages using the CDS Client API in a read-only fashion (no data is allowed to be input from networks or locations outside of the TSC) to create static or dynamic web pages displaying data stored on the CDS Servers.

8.2.3 Data Rates

This section describes network bandwidth used for various parts of the ground systems.

8.2.3.1 Telescience Support Center

Data rates for the TSC WAN, negotiable via the Ground Data Services Data Set, are as specified in SSP 54001, section 2736.08. The construction of the internal network at the TSC is specified in TSC-DOC-004.

8.2.3.2 Internet

Data rates for Internet access to the ESN, which interfaces with the GRC Integrated Desktop Environment Network, are variable depending on source and destination..

8.3 Operations

8.3.1 Data Storage

Data stores on-ground consist of raw and processed telemetry data and ground ancillary data. CDS hardware will provide this data storage function.

8.3.1.1 Raw Telemetry

Raw telemetry data will be formatted by TReK as packet record files as specified in TREK-USER-003.

8.3.1.2 Processed Telemetry

Processed telemetry will be formatted by the PD.

8.3.2 Training

Training of the FCF and PD GSP shall be performed as described in FCF-PLN-0788.

9.0 ENVIRONMENTAL INTERFACES

The payload must be compatible with the ISS atmospheric and radiation environments defined in this section.

9.1 Atmosphere Requirements

Payload components shall be compatible with the atmospheric environments defined in SSP 57000. The sections that apply to the payload components are provided in TABLE 49 .

TABLE 49 SSP 57000 ATMOSPHERE INTERFACE REQUIREMENTS

SSP 57000 Section	Title
3.9.1.1	Pressure
3.9.1.2	Temperature
3.9.1.3	Humidity
3.9.2.2	Oxygen Consumption
3.9.2.3	Chemical Releases

9.2 Radiation Requirements

Payload components shall be compatible with the radiation environments defined in SSP 57000. The sections that apply to the payload components are identified in TABLE 50 .

TABLE 50 SSP 57000 RADIATION INTERFACE REQUIREMENTS

SSP 57000 Section	Title
3.9.3.1	Integrated Rack Contained or Generated Ionizing Radiation
3.9.3.2	Ionizing Radiation Dose
3.9.3.3	Single Event Effect (SEE) Ionizing Radiation

9.3 Additional Requirements

Payload components shall be compatible with the additional environments defined in SSP 57000 Table 3.9.4-1.

10.0 LAPTOP COMPUTERS AND SOFTWARE

This section defines the hardware and software interfaces of the laptop computer utilized by a payload for crew command, control and monitoring.

10.1 Laptop Computer

The Station Support Computer (SSC) is a laptop computer available for use by the crew. Its main function is to allow the crew to perform ISS support functions that are not related to any payload specifically. The SSC will be used to guide the crew through required actions and decisions that cannot be completed from the ground but are required for the CIR to continue to perform science objectives.

SSC software can be used to monitor the payload, send requests, display video, etc., which are subject to operational and hardware-sharing constraints. The majority of commanding and monitoring will be performed through ground software.

The SSC will not be dedicated to the FCF, as its primary function is ISS support. The crew will connect the SSC to the rack as needed.

10.2 Payload-Provided Software Requirements

10.2.1 Payload Graphical User Interface Development

The payload-provided Graphical User Interface (GUI) software shall be developed using Java programming language. The PD shall develop GUI software utilizing the FCF-provided Application Programming Interface (API) as documented in FCF-DOC-1760. This API includes Java classes to support command and telemetry. The GUI software will be physically up-linked to the ISS from the GRC TSC and stored on the FCF I/O Processor embedded web server.

The crew will invoke the SSC's web browser to request a predetermined web page from the FCF I/O Processor's embedded web server. The web server will then serve the HyperText Markup Language (HTML) and Java applet-based GUI, which contain the PD-provided GUI. An overview of this architecture is shown in FIGURE 76.

10.2.2 Payload Displays

Every payload display shall be developed in accordance with the payload display review process defined in SSP 50313. The Payload Display Review Panel at Marshall Space Flight Center (MSFC) will approve all displays.

10.2.3 Software Safety Requirements

All software provided for the operation of the payload components shall be considered zero-fault tolerant as detailed in NSTS 1700.7B, 201.1e(1).

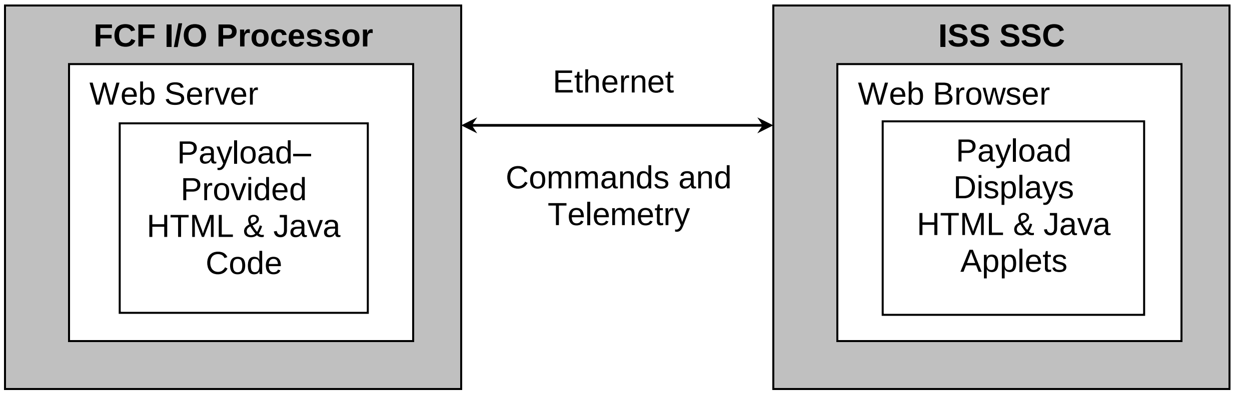


FIGURE 76 OVERVIEW OF PAYLOAD-PROVIDED DISPLAY SOFTWARE ARCHITECTURE

11.0 HUMAN FACTORS INTERFACE REQUIREMENTS

The PD shall be cognizant of various ISS human factors requirements and considerations in the design of a payload. The PD will determine the applicability of each requirement with the Human Factors Implementation Team (HFIT). The HFIT will then maintain configuration management of the applicability via form 881. These requirements are levied to protect the crew from exposure to hazardous conditions. Human factors requirements of SSP 57000 that apply to the payload are identified in TABLE 51 . Fields that are grayed-out indicate that the section is only a title in SSP 57000 or the text in that section does not have a requirement.

TABLE 51 SSP 57000 HUMAN FACTORS INTERFACE REQUIREMENTS

SSP 57000 Section No.	SSP 57000 Section Title
3.12.1	Strength Requirements
3.12.2	Body Envelope and Reach Accessibility
3.12.2.1	Adequate Clearance
3.12.2.2	Accessibility
3.12.2.3	Full Size Range Accommodation
3.12.3	Habitability
3.12.3.1	Housekeeping
3.12.3.1.1	Closures or Covers
3.12.3.1.2	Built-In Control
3.12.3.1.5	One-Handed Operation
3.12.3.2	Touch Temperature
3.12.3.2.1	Continuous/Incidental Contact - High Temperature
3.12.3.2.2	Continuous/Incidental Contact – Low Temperature
3.12.3.4	Lighting Design
3.12.4	Structural/Mechanical Interfaces
3.12.4.2	Payload Hardware Mounting
3.12.4.2.1	Equipment Mounting
3.12.4.2.2	Drawers and Hinged Panels
3.12.4.2.5	Alignment
3.12.4.2.6	Slide-Out Stops
3.12.4.2.7	Push-Pull Force
3.12.4.2.8	Access
3.12.4.2.8.1	Covers
3.12.4.2.8.2	Self-Supporting Covers
3.12.4.2.8.4	Unique Tools
3.12.4.3	Connectors
3.12.4.3.1	One-Handed Operation
3.12.4.3.2	Accessibility
3.12.4.3.3	Ease of Disconnect
3.12.4.3.4	Indication of Pressure/Flow
3.12.4.3.5	Self Locking
3.12.4.3.6	Connector Arrangement

SSP 57000 Section No.	SSP 57000 Section Title
3.12.4.3.7	Arc Containment
3.12.4.3.8	Connector Protection
3.12.4.3.9	Connector Shape
3.12.4.3.10	Fluid and Gas Line Connectors
3.12.4.3.11	Alignment Marks or Guide Pins
3.12.4.3.12	Coding
3.12.4.3.13	Pin Identification
3.12.4.3.14	Orientation
3.12.4.3.15	Hose/Cable Restraints
3.12.4.4	Fasteners
3.12.4.4.1	Non-Threaded Fasteners Status Indication
3.12.4.4.2	Mounting Bolt/Fastener Spacing
3.12.4.4.4	Multiple Fasteners
3.12.4.4.5	Captive Fasteners
3.12.4.4.6	Quick Release Fasteners
3.12.4.4.7	Threaded Fasteners
3.12.4.4.8	Over Center Latches
3.12.4.4.9	Winghead Fasteners
3.12.4.4.11	Fastener Head Type
3.12.4.4.12	One-Handed Actuation
3.12.4.4.14	Access Holes
3.12.5	Controls and Displays
3.12.5.1	Controls Spacing Design Requirements
3.12.5.2	Accidental Actuation
3.12.5.2.1	Protective Methods
3.12.5.2.2	Noninterference
3.12.5.2.3	Dead-Man Controls
3.12.5.2.4	Barrier Guards
3.12.5.2.5	Recessed Switch Protection
3.12.5.2.7	Position Indication
3.12.5.2.8	Hidden Controls
3.12.5.2.9	Hand Controllers
3.12.5.3	Valve Controls
3.12.5.4	Toggle Switches
3.12.6	Restraints and Mobility Aids
3.12.6.1	Stowage Drawer Contents Restraints
3.12.6.2	Stowage and Equipment Drawers/Trays
3.12.6.3	Captive Parts
3.12.6.4	Handle and Grasp Area Design Requirements
3.12.6.4.1	Handles and Restraints
3.12.6.4.3	Handle Location/Front Access
3.12.6.4.4	Handle Dimensions
3.12.6.4.5	Non-Fixed Handles Design Requirements
3.12.7	Identification Labeling
3.12.8	Color

SSP 57000 Section No.	SSP 57000 Section Title
3.12.9	Crew Safety
3.12.9.1	Electrical Hazards
3.12.9.1.1	Mismatched
3.12.9.1.4	Overload Protection
3.12.9.1.4.1	Device Accessibility
3.12.9.1.4.2	Extractor-Type Fuse Holder
3.12.9.1.4.3	Overload Protection Location
3.12.9.1.4.4	Overload Protection Identification
3.12.9.1.4.5	Automatic Restart Protection
3.12.9.2	Sharp Edges and Corners Protection
3.12.9.3	Holes
3.12.9.4	Latches
3.12.9.5	Screws and Bolts
3.12.9.6	Securing Pins
3.12.9.7	Levers, Cranks, Hooks, and Controls
3.12.9.8	Burrs
3.12.9.9	Locking Wire
3.12.9.10	Audio Devices (Displays)
3.12.9.12	Egress
3.12.10	Payload In-Flight Maintenance

11.1 Portable Item Temporary Stowage Restraints

11.1.1 Tether Points

Tether points used on portable items for temporary stowage or placement purposes shall meet the structural margin of safety requirements specified in SSP 52005. These tether points shall be physically compatible with standard ISS tethers, or the PD shall be responsible for providing the appropriate tethers.

11.1.2 Temporary Stowage/Placement

A method shall be established for securing payload stowage items in place during on-orbit operations.

11.2 Waste Management

All payloads shall meet the requirements contained in SSP 50481.

11.3 Mechanical Energy Devices

Mechanical devices capable of storing energy (such as springs, spring-loaded levers, and torsion bars) shall be designed with safety features incorporated (such as locks, protective devices, and/or warning placards).

11.4 Crew Safety

11.4.1 Laser and Radiation Source Requirements

Lasers shall not be operated with the rack doors open. All lasers utilized by the payload will demonstrate compatibility with the following containment requirements.

11.4.1.1 Laser Design and Operation In Compliance with ANSI Standard Z136.1-1993

Payloads employing lasers shall be designed and operated in accordance with the ANSI Standard Z136.1-1993. The hazard shall specifically address each occurrence where the laser does not meet ANSI Standard Z136.1-1993 requirements.

11.4.1.2 Non-Ionizing Radiation

Payload non-ionizing emissions shall not exceed the limits specified in SSP 50005 section 5.7.3.2.1 for RF, laser and ultraviolet exposure.

11.4.1.3 Safe Operation

The PD shall provide procedures for the safe operation of laser and optical radiation sources.

11.4.1.4 Accidental Exposures

Payloads shall prevent accidental exposures from laser and optical radiation.

11.4.1.5 Laser and Optical Radiation Monitoring

The PD shall provide monitoring and warning systems consistent with the potential hazard from each identified source of laser and optical radiation.

11.4.2 Personnel Protection Devices

The PD shall provide protective equipment, eyewear and clothing, based on the safety requirements and the results of an electromagnetic hazard analysis.

11.4.3 Inadvertent Adiabatic Combustion

The PD shall perform an analysis to determine the maximum ratio amounts of fuel, oxygen, and/or diluent for each fuel mixture to preclude inadvertent rapid expansion of gasses caused by adiabatic combustion. This analysis shall be completed using CIR-DOC-1072.

12.0 MATERIALS AND PARTS INTERFACE REQUIREMENTS

12.1 Materials and Processes Use and Selection

Materials and processes used in the design, fabrication, and assembly of a payload shall comply with NSTS 1700.7B and NSTS 1700.7B/ISS Addendum sections 208.3 and 209 in their entirety, SSP 30233 and MRD-PLN-0008. Commercial Off-the-Shelf (COTS) parts used in integrated racks shall meet these same materials requirements.

The NASA Materials and Processes Intercenter Agreement for ISS payloads establishes the process for selection and certification of materials used in payload components according to the safety requirements of NSTS 1700.7B and NSTS 1700.7B/ISS Addendum, sections 208.3 and 209 in their entirety.

Whenever possible, materials shall be selected that have already been shown to meet the applicable acceptance test criteria. Existing test data is compiled in the NASA MSFC Materials and Processes Technical Information System (MAPTIS) electronic database. A hardcopy version of the MAPTIS database, MSFC-HDBK-527/JSC 09694, is published periodically as a joint document.

12.1.1 Acceptance Criteria for Stress Corrosion Cracking

Metallic materials that have a high resistance (A-rated) to Stress Corrosion Cracking (SCC) according to the criteria of MSFC-STD-3029 shall be used whenever possible: especially for structural members, such as payload structures, support bracketry, and mounting hardware, and for structures where failure could result in a critical or catastrophic hazard.

12.1.2 Hazardous Materials and Compatibility

The use of materials, chemicals, and fluids that could create a toxic or hazardous condition for the crew, or that contribute to the deterioration of components in service, shall be given special attention to assure adequate containment and compatibility.

12.1.2.1 Toxic Fuels and Toxic Combustion By-Products

The PD shall provide a JSC approved toxicity analysis for all potential fuels and combustion by-products. For PD’s using the GC, the analyses shall show that Criticality 0 is not exceeded.

12.1.3 Test and Acceptance Criteria for Flammability

The payload materials shall be nonflammable or self-extinguishing per the test criteria of NASA-STD-6001 or shall be evaluated for flammability configuration in accordance with the guideline of NSTS 22648 or JSC 29353.

12.1.3.1 High Oxygen Concentration Compatibility

The PD shall perform an oxygen assessment of all internal Combustion Chamber payload hardware and CIR Adsorber Cartridge internal materials. This assessment shall be performed at the maximum concentration and pressure that could fill the Combustion Chamber from a single oxygen bottle. The PD shall provide a listing of all materials via a Material Identification Usage List. This information shall include all exposed materials and a cross-sectional view of hardware that contains O_2 with the materials identified.

12.1.4 Test and Acceptance Criteria for Toxic Offgassing (Toxicity)

Payload components located in habitable areas shall meet the toxicity offgassing acceptance requirements of NASA-STD-6001, Test 7.

12.1.5 Soot Production

Soot containing Polynuclear Aromatic Hydrocarbons (PAHs), which are considered carcinogenic, could adhere to the chamber door, windows, sidewalls, CIA, connectors and side rails. These materials have the potential to break free and contaminate the habitable atmosphere causing crew illness if inhaled or floating particles could cause injury to the eyes. PDs shall be limited to one soot producing experiment per increment.

12.1.5.1 Soot Producing Experiments

Experiments shall produce at or below the Spacecraft Maximum Allowable Concentration (SMAC) value and the combined T value less that or equal to 1. The PD shall provide an analysis of the type, amount and constituents of the soot produced.

12.1.5.1.1 Additional Containment

The PD shall provide additional containment if the experiment cannot meet the SMAC limit.

12.1.5.1.2 Soot Contingency Kit

For soot producing experiments, the PD shall provide a contingency kit for use by the crew for off nominal containment of excess soot.

12.1.5.2 Cleaning the CIR Combustion Chamber and Payload Components

For payload experiments that generate soot or particulate contamination, the PD shall investigate the need for cleaning the Combustion Chamber and payload components. The PD shall work with the FCF Utilization Team to provide specific crew procedures, materials and equipment for cleaning.

12.2 Galvanic Corrosion

Payloads that utilize the ISS aqueous fluid systems shall use materials compatible with these systems according to MSFC-SPEC-250, Table III, or shall use materials that will not create a potential greater than 0.25 VDC with the ISS system materials due to a dissimilar metal couple.

12.3 Fungus-Resistant Materials

Payload components shall utilize fungus-resistant materials as defined in SSP 57000, section 3.11.4.

12.4 Cleanliness

Payload components shall meet cleanliness requirements for the integrated rack as specified in SSP 57000, section 3.11.3.

13.0 FIRE PROTECTION

Payload components must not constitute an uncontrolled fire hazard to the ISS, FCF, or other payloads. The PD must analyze all aspects of the payload components, interfaces, materials, and operations to determine the level of fire risk. A fire event detection smoke sensor is an integral part of the FCF. However, for a payload to take advantage of this feature it must interface with the avionics air-cooling loop. Smoke sensor activation is the only detection method that will result in a Class I fire alarm (illumination of the FIRE lamp on the module Caution and Warning (C&W) panel after two consecutive “smoke detected” signals from the smoke sensor).

A fire event location is defined as any partitioned volume inside a rack that contains a potential fire source. If a payload contains several such volumes (excluding sealed containers), each volume shall be treated as a separate fire event location. Detection is defined as a method for determining that a fire event or potential fire event has occurred within a fire event location.

In addition to the smoke sensor, the rack provides a smoke sensor indicator (a red Light Emitting Diode (LED)) on the front of the rack for crew visual identification of the location and a PFE access port.

13.1 Fire Event Prevention Requirements

The payload shall comply with the fire prevention requirements of SSP 57000, section 3.10.1.

The PD shall provide an assessment of the current design and worst-case failure scenarios (including the effects of loss of power and release of oxygen outside of the payload) to demonstrate compliance with the above requirements.

13.2 Payload Parameter Monitoring

Payload components that are not in the airflow of the rack avionics air-cooling loop shall comply with the parameter monitoring requirements of SSP 57000, section 3.10.2.2.1.

14.0 MDCA INTERFACES

14.1 MDCA Applicability Matrix

The requirements from FCF-ICD-CIR-MDCA that apply to the experiments of MDCA are identified in TABLE 52 . Fields marked by 'N/A' indicate that MDCA will not use that particular interface for the experiment. Fields grayed-out indicate that the FCF-ICD-CIR-MDCA section is just a title, the section is "N/A" in the ICD for that interface, or the text in that section does not have a requirement with it.

TABLE 52 MDCA APPLICABILITY MATRIX

ICD Section Number	ICD Section Title	MDCA	SSP 57000 Section Reference
3.0	Physical and Mechanical Interfaces		
3.1	Optics Bench		
3.1.1	Universal Mounting Locations	N/A	N/A
3.1.1.1	Universal Mounting Location Mounting Interface	N/A	N/A
3.1.1.2	Universal Mounting Location Threaded Mounting Holes	N/A	N/A
3.1.1.3	Universal Mounting Location Electrical Connector	N/A	N/A
3.1.1.4	Universal Mounting Location Air-Cooling Interface	N/A	N/A
3.1.1.5	FCF Universal Mounting Location Latch Handle Provisions	N/A	N/A
3.1.1.6	Universal Mounting Location Mounted Hardware Envelope		
3.1.1.6.1	Payload-Provided Components	N/A	N/A
3.1.1.6.2	CIR-Provided Components	N/A	N/A
3.1.2	Principal Investigator Location		
3.1.2.1	Principal Investigator Location Mounting Holes	X	N/A
3.1.2.2	Principal Investigator Location Threaded Mounting Holes	X	N/A
3.1.2.3	Principal Investigator Location Electrical Connectors	X	N/A
3.1.2.4	Principal Investigator Location Air-Cooling Interface	X	N/A
3.1.2.5	Principal Investigator Location Avionics Package Envelope	X	N/A
3.1.3	Auxiliary Interface Connectors		
3.1.3.1	Auxiliary Electrical Interface Connector	N/A	N/A
3.1.3.2	Auxiliary Fiber Optic Connector	N/A	N/A
3.1.3.3	Auxiliary Cooling Water Interface		
3.1.3.3.1	Optics Bench Cooling Water Quick-Disconnect Fitting	N/A	N/A
3.2	Combustion Chamber		
3.2.1	Interface Resource Ring		
3.2.1.1	CIR Manifold #3 Interface		
3.2.1.1.1	CIR Manifold #3 Quick-Disconnect Fitting	N/A	N/A
3.2.1.1.2	CIR Manifold #3 Quick-Disconnect Fitting Additional Controls	N/A	N/A
3.2.1.2	Static Mixer Gas Supply Interface		
3.2.1.2.1	Static Mixer Gas Supply Quick-Disconnect Fitting	N/A	N/A
3.2.1.3	CIR Manifold #4 Interface		
3.2.1.3.1	CIR Manifold #4 Quick-Disconnect Fitting	N/A	N/A
3.2.1.4	Gas Chromatograph Interface		
3.2.1.4.1	Gas Chromatograph Quick-Disconnect Fitting	N/A	N/A

ICD Section Number	ICD Section Title	MDCA	SSP 57000 Section Reference
3.2.1.5	Cooling Water Interface		
3.2.1.5.1	Combustion Chamber Cooling Water Quick-Disconnect Fitting	X	N/A
3.2.1.6	Government Furnished Accumulator	X	N/A
3.2.1.7	Electrical Feed-Throughs	X	N/A
3.2.1.8	Principal Investigator Port	N/A	N/A
3.2.1.8.1	Principal Investigator Port Safety Requirements	N/A	N/A
3.2.1.8.2	Principal Investigator Port Threaded Boss Fitting	N/A	N/A
3.2.1.8.3	Principal Investigator Port Threaded Boss Fitting Envelope	N/A	N/A
3.2.1.9	Vacuum Exhaust Port	N/A	N/A
3.2.1.10	Combustion Chamber Grounding Interface	N/A	N/A
3.2.2	CIR Chamber Fan Interface		
3.2.3	Rear Access Port	N/A	N/A
3.2.3.1	Rear Access Port Safety Requirements	N/A	N/A
3.2.3.2	Rear Access Port Envelope	N/A	N/A
3.2.4	Window Ports		
3.2.4.1	Window Assembly General Requirements	N/A	N/A
3.2.4.2	Window Assembly Safety Requirements	N/A	N/A
3.2.5	Mounting Rails	X	N/A
3.2.6	Axial Locating Slots	X	N/A
3.2.7	Vacuum Exhaust System Interface	N/A	N/A
3.2.8	Vacuum Resource System Interface		
3.2.8.1	Vacuum Resource System Quick-Disconnect Fitting	N/A	N/A
3.2.8.2	Vacuum Resource System Quick-Disconnect Fitting Envelope	N/A	N/A
3.2.9	Internal Volume Envelope		
3.2.9.1	Internal Volume with CIR Chamber Fan	X	N/A
3.2.9.2	Internal Volume with CIR Rear End Cap Plug	N/A	N/A
3.2.9.3	Internal Volume Requirements When Using CIR Manifold #3	N/A	N/A
3.3	Fuel/Oxidizer Management Assembly		
3.3.1	FOMA Supply Manifold Gas Mixture Requirements	X	N/A
3.3.1.1	Gas Bottle Maximum Pressure	X	N/A
3.3.1.2	Gas Bottle Maximum Oxygen Concentration	X	N/A
3.3.2	GC Gas Supply Package Carrier and Check Gas Requirements	N/A	N/A
3.3.2.1	Check Gas Mixture Requirements	N/A	N/A
3.3.2.2	Carrier Gas Requirements	N/A	N/A
3.3.3	CIR Adsorber Cartridge	X	N/A
3.3.4	Vent Manifold O_2 Sensor Port	N/A	N/A
3.4	CIR-Provided Diagnostics		
3.4.1	FCF Diagnostic Control Module		
3.4.1.1	FCF Diagnostic Control Module Kinematic Mount	N/A	N/A
3.4.1.2	FCF Diagnostic Control Module Air-Cooling Port	N/A	N/A
3.4.1.3	FCF Diagnostic Control Module Electrical Connector	N/A	N/A
3.4.1.4	FCF Diagnostic Control Module Electrical Connector Envelope	N/A	N/A
3.4.2	CIR High Bit Depth/Multispectral Imaging Package		
3.4.3	CIR High Frame Rate/High Resolution Imaging Package		

ICD Section Number	ICD Section Title	MDCA	SSP 57000 Section Reference
3.4.4	CIR Low Light Level Ultraviolet Imaging Package		
3.4.5	CIR Low Light Level Infrared Imaging Package		
3.4.6	CIR Optics Housing Module	N/A	N/A
3.4.6.1	CIR Optics Housing Module Kinematic Mount	N/A	N/A
3.4.6.2	Four-Flange Interface	X	N/A
3.4.6.3	Three-Flange Interface	N/A	N/A
3.4.6.4	CIR Optics Housing Module Electrical Connector	N/A	N/A
3.4.6.5	CIR Optics Housing Module Air-Cooling Duct	N/A	N/A
3.4.7	CIR Illumination Control Module		
3.4.8	FCF Image Processing and Storage Unit		
3.4.8.1	FCF Image Processing and Storage Unit Fiber Optic Connector	N/A	N/A
3.4.8.2	FCF Image Processing and Storage Unit Fiber Optic Connector Cable	N/A	N/A
3.4.9	FCF Image Processing and Storage Unit – Analog		
3.5	120 VDC Power Interface		
3.5.1	120 VDC Power Interface Connector	N/A	N/A
3.5.2	120 VDC Power Interface Connector Envelope	N/A	N/A
3.6	CIR/Payload Coordinate System		
3.6.1	CIR Coordinate System		
3.6.2	Optics Bench Coordinate System		
3.7	Dimensions and Tolerances	X	N/A
3.8	Mass and Center of Gravity		
3.8.1	On-Orbit Center of Gravity Envelope	X	N/A
3.8.2	Mass Allocation	X	N/A
3.9	Stowage Provisions		
3.9.1	Multi-Purpose Logistics Module Interfaces		
3.9.1.1	Multi-Purpose Logistics Module Late/Early Access Requirements	N/A	3.1.1.2.1
3.9.2	Cargo Transfer Bags	X	N/A
3.9.3	Middeck Payload Transportation System	N/A	N/A
3.10	Ground Support Equipment		
4.0	Structural Interfaces		
4.1	Optics Bench	X	N/A
4.1.1	Universal Mounting Locations		
4.1.1.1	Universal Mounting Location Threaded Mounting Holes	N/A	N/A
4.1.1.2	Universal Mounting Location Mounting Holes	N/A	N/A
4.1.1.3	Universal Mounting Location Electrical Connector		
4.1.1.4	Universal Mounting Location Air-Cooling Interface		
4.1.1.5	FCF Universal Mounting Location Latch Handle Provisions		
4.1.2	Principal Investigator Location		
4.1.2.1	Principal Investigator Location Threaded Mounting Holes	X	N/A
4.1.2.2	Principal Investigator Location Mounting Holes	X	N/A
4.1.3	Auxiliary Interface Connectors		
4.2	Combustion Chamber	X	N/A
4.2.1	Interface Resource Ring		
4.2.2	CIR Rear End-Cap Port Plug Interface		
4.2.3	Rear Access Port		

ICD Section Number	ICD Section Title	MDCA	SSP 57000 Section Reference
4.2.4	Window Ports		
4.2.5	Mounting Rails	X	N/A
4.2.6	Axial Locating Slots		
4.2.7	Vacuum Exhaust System Interface		
4.2.8	Vacuum Resource System Interface		
4.3	Fuel/Oxidizer Management Assembly		
4.4	CIR-Provided Diagnostics		
4.4.1	FCF Diagnostic Control Module		
4.4.1.1	FCF Diagnostic Control Module Kinematic Mount	N/A	N/A
4.4.1.2	FCF Diagnostic Control Module Air-Cooling Port		
4.4.1.3	FCF Diagnostic Control Module Electrical Connector		
4.4.2	CIR High Bit Depth/Multispectral Imaging Package		
4.4.3	CIR High Frame Rate/High Resolution Imaging Package		
4.4.4	CIR Low Light Level Ultraviolet Imaging Package		
4.4.5	CIR Low Light Level Infrared Imaging Package		
4.4.6	CIR Optics Housing Module		
4.4.7	CIR Illumination Control Module		
4.4.8	FCF Image Processing and Storage Unit		
4.4.9	FCF Image Processing and Storage Unit – Analog		
4.5	120 VDC Power Interface		
4.6	Payload Launch and Landing Loads	X	3.1.1.3-4
4.7	Random Vibration	X	N/A
4.8	On-Orbit Loads		
4.8.1	Crew Induced Loads	X	3.1.1.3-D
4.8.2	Other On-Orbit Loads	X	3.1.1.3-B
4.9	Payload Structural Design		
4.9.1	Structural Design	X	3.1.1.5-A
4.9.2	Fracture Control	X	3.1.1.5
4.10	Acoustics		
4.10.1	Payload-Generated Acoustic Noise		
4.10.1.1	Acoustic Noise Definitions		
4.10.1.2	Acoustic Noise Limits		
4.10.1.2.1	Continuous Noise Limits	X	N/A
4.10.1.2.2	Intermittent Noise Limits	X	N/A
4.10.1.2.3	Continuous Noise Sources with Intermittent Noise Features	X	N/A
4.10.1.3	Use of Vacuum Exhaust System	X	N/A
4.10.2	CIR Payload Acoustic Environment	X	N/A
4.11	Depressurization/Repressurization Requirements		
4.11.1	U.S. Laboratory Maximum Depressurization/Repressurization Rates	X	3.1.1.5
4.11.2	MPLM Maximum Depressurization/Repressurization Rates	X	3.1.1.2-B
4.11.3	Portable Fire Extinguisher Discharge Rate	X	3.1.1.4-K
4.12	Ground Handling Environments		
4.12.1	Ground Handling Load Factors	X	N/A
4.12.2	Ground Handling Shock Criteria	X	N/A
4.13	Microgravity Disturbances		

ICD Section Number	ICD Section Title	MDCA	SSP 57000 Section Reference
4.13.1	Rack to Combustion Chamber Insert Interface Microgravity Environment		
4.13.1.1	CIR Quasi-Steady Environment		
4.13.1.2	CIR Vibratory Environment		
4.13.2	Payload Microgravity Disturbance Limit		
4.13.2.1	Payload Quasi-Steady Limit	X	N/A
4.13.2.2	Payload Vibratory Disturbance Limit	X	N/A
4.13.2.3	Payload Transient Impulse Limit	X	N/A
4.14	Constraints for PaRIS Operation of CIR		
5.0	Thermal/Fluids Interface		
5.1	Optics Bench		
5.1.1	Universal Mounting Locations		
5.1.1.1	Universal Mounting Location Mounting Holes		
5.1.1.2	Universal Mounting Location Electrical Connector		
5.1.1.3	Universal Mounting Location Air-Cooling Interface		
5.1.1.3.1	Airflow Rate to Universal Mounting Location Mounted Components	N/A	N/A
5.1.1.3.2	Air Supply Temperature to Universal Mounting Location Mounted Components		
5.1.1.3.3	Pressure Drop Across Universal Mounting Location Mounted Components	N/A	N/A
5.1.1.4	FCF Universal Mounting Location Latch Handle Provisions		
5.1.2	Principal Investigator Location	X	N/A
5.1.3	Optics Bench Working Volume		
5.1.3.1	Airflow Rate to Optics Bench Mounted Components	X	N/A
5.1.3.2	Maximum Allowable Heat Dissipation from Optics Bench Mounted Components	X	N/A
5.1.3.3	Limitations on Heat Conducted to Structure for Optics Bench Mounted Components	X	N/A
5.2	Combustion Chamber		
5.2.1	Interface Resource Ring		
5.2.1.1	CIR Manifold #3 Interface		
5.2.1.1.1	CIR Manifold #3 Quick-Disconnect Fitting		
5.2.1.1.2	CIR Manifold #3 Temperature		
5.2.1.1.3	CIR Manifold #3 Maximum Pressure		
5.2.1.1.4	Gaseous Nitrogen Flow Rate	N/A	3.7.1.1
5.2.1.1.5	Gaseous Nitrogen Supply Temperature		
5.2.1.1.6	Gaseous Nitrogen Supply Pressure	N/A	3.7.1.1
5.2.1.1.7	Gaseous Nitrogen Quality		
5.2.1.2	Static Mixer Gas Supply Interface		
5.2.1.2.1	Static Mixer Gas Supply Quick-Disconnect Fitting		
5.2.1.2.2	Static Mixer Gas Flow Rate Supplied by the CIR Manifold #3 and CIR Manifold #2		
5.2.1.2.3	Total Static Mixer Gas Flow Rate		
5.2.1.2.4	Static Mixer Gas Supply Temperature		
5.2.1.2.5	Static Mixer Gas Supply Pressure		
5.2.1.2.6	Gaseous Nitrogen Quality		
5.2.1.3	CIR Manifold #4 Interface		

ICD Section Number	ICD Section Title	MDCA	SSP 57000 Section Reference
5.2.1.3.1	CIR Manifold #4 Quick-Disconnect Fitting		
5.2.1.3.2	CIR Manifold #4 Flow Rate		
5.2.1.3.3	CIR Manifold #4 Temperature		
5.2.1.4	Gas Chromatograph Interface		
5.2.1.4.1	Gas Chromatograph Quick-Disconnect Fitting		
5.2.1.4.2	Gas Sample Pressure		
5.2.1.4.3	Gas Oxygen Concentration		
5.2.1.5	Electrical Feed-Throughs		
5.2.1.6	Principal Investigator Port		
5.2.1.7	Vacuum Exhaust Port		
5.2.1.8	Combustion Chamber Grounding Interface		
5.2.2	CIR Rear End-Cap Port Plug Interface		
5.2.3	Rear Access Port		
5.2.4	Window Ports		
5.2.5	Mounting Rails		
5.2.6	Axial Locating Slots		
5.2.7	Vacuum Exhaust System Interface		
5.2.7.1	Vacuum Exhaust System Input Temperature Range		
5.2.7.2	Exhaust Gas Flow Rate when Not Using the CIR Adsorber Cartridge		
5.2.7.3	Exhaust Gas Flow Rate when Using the CIR Adsorber Cartridge		
5.2.7.4	Vacuum Exhaust System Acceptable Gases	X	3.6.1.5
5.2.7.5	Vacuum Exhaust System External Contamination Control	X	3.6.1.5
5.2.7.6	Vacuum Exhaust System Non-Reactive Gases	X	3.6.1.5
5.2.7.7	Vacuum Exhaust System Particulate Removal	X	3.6.1.5.3
5.2.7.8	Vacuum Exhaust System Input Dew Point		
5.2.7.9	Vacuum Exhaust System Oxygen Concentration Venting	X	3.6.1.5
5.2.8	Vacuum Resource System Interface		
5.2.8.1	Vacuum Resource System Throughput Limit	N/A	3.6.2.3
5.2.8.2	Vacuum Resource System Input Pressure Limit	N/A	3.6.2.2
5.2.8.3	Vacuum Resource System Maximum Design Pressure and Failure Tolerance	N/A	3.6.1.5
5.2.8.4	Vacuum Resource System Acceptable Gases	N/A	3.6.1.5
5.3	Fuel/Oxidizer Management Assembly		
5.3.1	Pressure Control		
5.3.2	Gas Blending		
5.3.2.1	Partial Pressure Gas Blending of Binary and Tertiary Mixtures		
5.3.2.2	Dynamic Gas Blending of Binary and Tertiary Mixtures		
5.3.3	Oxidizer Control During Combustion Events	N/A	N/A
5.3.4	Elimination of Toxic Materials	X	N/A
5.4	CIR-Provided Diagnostics		
5.4.1	FCF Diagnostic Control Module		
5.4.1.1	FCF Diagnostic Control Module Kinematic Mount		
5.4.1.2	FCF Diagnostic Control Module Air-Cooling Port		
5.4.1.2.1	Airflow Rate to FCF Diagnostic Control Module Mounted Components	N/A	N/A

ICD Section Number	ICD Section Title	MDCA	SSP 57000 Section Reference
5.4.1.2.2	Air Supply Temperature to FCF Diagnostic Control Module Mounted Components		
5.4.1.2.3	Pressure Drop across FCF Diagnostic Control Module Mounted Components	N/A	N/A
5.4.1.3	FCF Diagnostic Control Module Electrical Connector		
5.4.2	CIR High Bit Depth/Multispectral Imaging Package		
5.4.3	CIR High Frame Rate/High Resolution Imaging Package		
5.4.4	CIR Low Light Level Ultraviolet Imaging Package		
5.4.5	CIR Low Light Level Infrared Imaging Package		
5.4.6	CIR Optics Housing Module		
5.4.6.1	CIR Optics Housing Module Air-Cooling Port		
5.4.6.1.1	Airflow Rate to CIR Optics Housing Module Mounted Components	N/A	N/A
5.4.6.1.2	Air Supply Temperature to CIR Optics Housing Module Mounted Components		
5.4.6.1.3	Pressure Drop across CIR Optics Housing Module Mounted Components	N/A	N/A
5.4.6.2	CIR Optics Housing Module Electrical Connector		
5.4.7	CIR Illumination Control Module		
5.4.8	FCF Image Processing and Storage Unit		
5.4.9	FCF Image Processing and Storage Unit – Analog		
5.5	120 VDC Power Interface		
5.6	Cooling Water Interface		
5.6.1	Cooling Water Quick-Disconnect Fitting		
5.6.2	Cooling Water Flow Rate	X	3.5.1.4
5.6.3	Cooling Water Supply Temperature		
5.6.4	Cooling Water Return Temperature	X	3.5.1.6
5.6.5	Cooling Water Differential Pressure	X	3.5.1.3
5.6.6	Cooling Water Materials Compatibility	X	3.11.2
5.6.7	Cooling Water Charging	X	3.11.2
5.6.8	Cooling Water Thermal Expansion	X	3.5.1.2
5.6.9	Total Quantity of Cooling Water within the Payload Components	X	3.5.1.16
5.6.10	Cooling Water Leakage Rate	X	3.5.1.9
5.6.11	Cooling Water System Maximum Design Pressure	X	3.1.1.5
5.6.12	Fail Safe Design and Loss of Cooling Water	X	3.5.1.8
5.7	Government Furnished Accumulator		
6.0	Electrical Power and Data Interfaces		
6.1	Optics Bench		
6.1.1	Universal Mounting Locations		
6.1.1.1	Universal Mounting Location Mounting Holes		
6.1.1.2	Universal Mounting Location Electrical Connector		
6.1.1.2.1	Sync Bus	N/A	N/A
6.1.1.2.2	Analog Video	N/A	N/A
6.1.1.2.3	Controller Area Network Bus	N/A	N/A
6.1.1.2.4	Location Address	N/A	N/A
6.1.1.2.5	Ethernet	N/A	N/A
6.1.1.2.6	28 VDC Power	N/A	3.2.1.1.1

ICD Section Number	ICD Section Title	MDCA	SSP 57000 Section Reference
6.1.1.2.6.1	Normal Voltage Levels	N/A	N/A
6.1.1.2.6.2	Non-Normal Output Voltage Levels	N/A	3.2.1.3.4
6.1.1.2.6.3	Payload Load Input Impedance	N/A	N/A
6.1.1.2.6.4	Ripple Voltage Characteristics	N/A	3.2.1.3.4
6.1.1.2.6.5	Reverse Current	N/A	3.2.2.5
6.1.1.2.6.6	Wire Derating	N/A	3.2.3.1
6.1.1.2.6.7	Power Switches/Controls	N/A	3.2.5.3
6.1.1.2.6.8	Overload Protection	N/A	N/A
6.1.1.3	Universal Mounting Location Air-Cooling Interface		
6.1.1.4	FCF Universal Mounting Location Latch Handle Provisions		
6.1.2	Principal Investigator Location		
6.1.2.1	Principal Investigator Location Connector Interfaces	X	N/A
6.1.2.2	Principal Investigator Location Sync Bus	N/A	N/A
6.1.2.3	Principal Investigator Location Analog Video	X	N/A
6.1.2.4	Principal Investigator Location CAN Bus	X	N/A
6.1.2.5	Principal Investigator Location Location Address	X	N/A
6.1.2.6	Principal Investigator Location Ethernet	X	N/A
6.1.2.7	Principal Investigator Location Fiber Optic	N/A	N/A
6.1.2.8	Principal Investigator Location 28 VDC Power	X	N/A
6.1.2.8.1	Normal Voltage Levels	X	N/A
6.1.2.8.2	Non-Normal Output Voltage Levels	X	3.2.1.3.4
6.1.2.8.3	Payload Load Input Impedance	X	N/A
6.1.2.8.4	Ripple Voltage Characteristics	X	3.2.1.3.4
6.1.2.8.5	Reverse Current	X	3.2.2.5
6.1.2.8.6	Wire Derating	X	3.2.3.1
6.1.2.8.7	Power Switches/Controls	N/A	3.2.5.3
6.1.2.8.8	Overload Protection	X	N/A
6.1.3	Auxiliary Interface Connectors	N/A	N/A
6.2	Combustion Chamber		
6.2.1	Interface Resource Ring		
6.2.1.1	Electrical Feed-Throughs		
6.2.1.1.1	Connector Interfaces		
6.2.1.1.1.1	Electrical Feed-Through JCTC5	X	N/A
6.2.1.1.1.2	Electrical Feed-Through JCTC6	N/A	N/A
6.2.1.1.1.3	Electrical Feed-Through JCTC7	X	N/A
6.2.1.1.1.4	Electrical Feed-Through JCTC8	X	N/A
6.2.1.1.1.5	Fiber Optic Feed-Through JCTC10	N/A	N/A
6.3	Fuel/Oxidizer Management Assembly		
6.4	CIR-Provided Diagnostics		
6.4.1	FCF Diagnostic Control Module		
6.4.1.1	FCF Diagnostic Control Module Kinematic Mount		
6.4.1.2	FCF Diagnostic Control Module Air-Cooling Port		
6.4.1.3	FCF Diagnostic Control Module Electrical Connector		
6.4.1.3.1	Motor and Sensor Interface/Camera Control and Power	N/A	N/A
6.4.1.3.2	Tunable/RGB Filter		
6.4.2	CIR High Bit Depth/Multispectral Imaging Package		
6.4.3	CIR High Frame Rate/High Resolution Imaging Package		

ICD Section Number	ICD Section Title	MDCA	SSP 57000 Section Reference
6.4.4	CIR Low Light Level Ultraviolet Imaging Package		
6.4.5	CIR Low Light Level Infrared Imaging Package		
6.4.6	CIR Optics Housing Module		
6.4.6.1	CIR Optics Housing Module Electrical Connector	N/A	N/A
6.4.7	CIR Illumination Control Module		
6.4.8	FCF Image Processing and Storage Unit		
6.4.8.1	FCF Image Processing and Storage Unit Fiber Optic Interface	N/A	N/A
6.4.9	FCF Image Processing and Storage Unit – Analog		
6.5	120 VDC Power Interface		
6.5.1	120 VDC Power Interface Connector	N/A	N/A
6.5.2	120 VDC Power Requirements	N/A	N/A
6.6	Nominal Power Consumption		
6.6.1	Available Direct Current Power		
6.7	Limitations on Payload Utilization of Electrical Power		
6.7.1	Payload Electrical Safety/Hazards		
6.7.1.1	Batteries	N/A	N/A
6.7.1.2	Safety-Critical Circuits	N/A	N/A
6.7.1.3	FCF Rack Door Switch	N/A	N/A
6.7.2	Emergency Operational Modes	X	N/A
6.8	Electrical Connectors		
6.8.1	Connector Pins/Sockets	X	3.2.5.1.1
6.8.2	Electrical Connector Mating/Demating	X	3.2.5.1.1
7.0	Electromagnetic Compatibility		
7.1	Electromagnetic Compatibility	X	3.2.4
7.1.1	Emission and Susceptibility Limits		
7.1.1.1	Compatibility	X	3.2.4
7.1.1.2	Conducted Emissions	X	3.2.4
7.1.1.3	Conducted Susceptibility	X	3.2.4
7.1.1.4	Radiated Emissions	X	3.2.4
7.1.1.5	Radiated Susceptibility	X	3.2.4
7.1.2	Electrostatic Discharge	X	3.2.4.5
7.1.3	Payload-Produced Alternating Current Magnetic Fields	X	3.2.4
7.1.4	Payload-Produced Direct Current Magnetic Fields	X	3.2.4
7.1.5	Corona	X	3.2.4.8
7.1.6	Lightning	X	3.2.4.9
7.1.7	EMI Susceptibility for Safety-Critical Circuits	N/A	3.2.4.10
7.2	Avionics Electrical Compatibility - Shuttle and ISS		
7.2.1	Electrical Bonding	X	3.2.4.2
7.2.1.1	Electrical Bonding of Payload Components	X	3.2.4.2
7.2.1.2	Electrical Bonding of Payload Structures		
7.2.1.2.1	Payload-to-CIR Main Bond		
7.2.1.2.1.1	Primary Payload Power Connector Bond	X	3.2.4.2
7.2.1.2.1.2	Payload-to-CIR Mated Surface Bond	X	3.2.4.2
7.2.1.2.1.3	Payload-to-CIR and Fluid Line Bonding	N/A	3.2.4.2
7.3	Power Circuit Isolation and Grounding	X	N/A
7.3.1	CIR 28 VDC Primary Power Bus Isolation	X	3.2.2.2
7.3.2	Direct Current Power Ground Reference	X	3.2.4.1

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7.3.3	Payload Secondary Power Isolation and Grounding	X	3.2.4.1
7.3.4	Ground Support Equipment Isolation and Grounding	X	3.2.4.1
7.4	Signal Isolation and Grounding Requirements		
7.4.1	Ethernet	X	3.2.4.1
7.4.2	Controller Area Network Bus	X	3.2.4.1
7.4.3	Video	X	3.2.4.1
7.4.4	Shield References	X	3.2.4.1
8.0	Command and Data Handling Interfaces		
8.1	Flight Software Interfaces		
8.1.1	Optics Bench		
8.1.1.1	Universal Mounting Locations	N/A	N/A
8.1.1.1.1	Universal Mounting Location Location Address	N/A	N/A
8.1.1.1.2	Universal Mounting Location Sync Bus		
8.1.1.1.3	Universal Mounting Location Analog Video		
8.1.1.1.4	Universal Mounting Location CAN Bus	N/A	N/A
8.1.1.1.5	Universal Mounting Location Ethernet	N/A	N/A
8.1.1.2	Principal Investigator Location	X	N/A
8.1.1.2.1	Principal Investigator Location Location Address	X	N/A
8.1.1.2.2	Principal Investigator Location Sync Bus		
8.1.1.2.3	Principal Investigator Location Analog Video		
8.1.1.2.4	Principal Investigator Location CAN Bus	X	N/A
8.1.1.2.5	Principal Investigator Location Ethernet	X	N/A
8.1.1.3	Auxiliary Interface Connectors		
8.1.2	Combustion Chamber		
8.1.2.1	Interface Resource Ring		
8.1.3	Fuel/Oxidizer Management Assembly		
8.1.4	CIR-Provided Diagnostics		
8.1.4.1	FCF Diagnostic Control Module	N/A	N/A
8.1.4.1.1	FCF Diagnostic Control Module CAN Bus	N/A	N/A
8.1.4.1.2	FCF Diagnostic Control Module Ethernet		
8.1.4.1.3	FCF Diagnostic Control Module RS-232	N/A	N/A
8.1.4.2	CIR High Bit Depth/Multispectral Imaging Package		
8.1.4.3	CIR High Frame Rate/High Resolution Imaging Package		
8.1.4.4	CIR Low Light Level Ultraviolet Imaging Package		
8.1.4.5	CIR Low Light Level Infrared Imaging Package		
8.1.4.6	CIR Illumination Control Module	N/A	N/A
8.1.4.6.1	CIR Illumination Control Module CAN Bus	N/A	N/A
8.1.4.6.2	CIR Illumination Control Module Ethernet		
8.1.4.6.3	CIR Illumination Control Module RS-232	N/A	N/A
8.1.4.7	FCF Image Processing and Storage Unit		
8.1.4.8	FCF Image Processing and Storage Unit-Analog		
8.1.5	FCF Mass Data Storage Unit	N/A	N/A
8.1.6	120 VDC Power Interface		
8.1.7	Additional Flight Software Interfaces		
8.1.7.1	Common Base Class Software Interface		
8.1.7.2	Data Management Software Interface		
8.1.7.2.1	FCF Input/Output Processor File Structure	N/A	N/A

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8.1.7.2.2	Data Management Commands	N/A	N/A
8.1.7.2.3	Data Summary	N/A	N/A
8.1.7.3	Required States	N/A	N/A
8.1.7.3.1	Initialization State		
8.1.7.3.2	Operational State	X	N/A
8.1.7.3.2.1	Idle State	X	N/A
8.1.7.3.3	Off-Nominal State		
8.1.7.3.4	Safed State		
8.1.7.4	Command Requirements	X	N/A
8.1.7.4.1	Routed Commands		
8.1.7.4.2	Direct Commands	N/A	N/A
8.1.7.4.3	Not Available Commands		
8.1.7.5	Telemetry Requirements	X	N/A
8.1.7.6	Error Handling Requirements	N/A	N/A
8.1.7.7	Internet Protocol Address Assignments	N/A	N/A
8.2	Ground Software Interfaces		
8.2.1	Data Formats		
8.2.1.1	Command Formats	X	N/A
8.2.1.2	Telemetry Formats		
8.2.1.2.1	Health and Status Telemetry		
8.2.1.2.2	Engineering and Science Telemetry		
8.2.1.3	File Formats		
8.2.1.4	Archive Formats		
8.2.1.5	Compression Algorithms		
8.2.2	Communication Protocols		
8.2.2.1	Commanding	X	N/A
8.2.2.2	Telemetry		
8.2.2.2.1	Video Data		
8.2.2.2.2	Downlinks		
8.2.2.2.3	Uplinks		
8.2.2.3	Archive Storage and Retrieval	X	N/A
8.2.2.4	Web Server	X	N/A
8.2.3	Data Rates		
8.2.3.1	Telescience Support Center		
8.2.3.2	Internet		
8.3	Operations		
8.3.1	Data Storage		
8.3.1.1	Raw Telemetry		
8.3.1.2	Processed Telemetry		
8.3.2	Training	X	N/A
9.0	Environmental Interfaces		
9.1	Atmosphere Requirements	X	3.9.1.1 3.9.1.2 3.9.1.3 3.9.2.2 3.9.2.3

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9.2	Radiation Requirements	X	3.9.3.1 3.9.3.2 3.9.3.3
9.3	Additional Requirements	X	3.9.4
10.0	Laptop Computers and Software		
10.1	Laptop Computer		
10.2	Payload-Provided Software Requirements		
10.2.1	Payload Graphical User Interface Development	X	N/A
10.2.2	Payload Displays	X	N/A
10.2.3	Software Safety Requirements	X	N/A
11.0	Human Factors Interface Requirements	**X**	**See TABLE 51**
11.1	Portable Item Temporary Stowage Restraints		
11.1.1	Tether Points	X	N/A
11.1.2	Temporary Stowage/Placement	X	N/A
11.2	Waste Management	X	N/A
11.3	Mechanical Energy Devices	N/A	3.12.5.2.1
11.4	Crew Safety		
11.4.1	Laser and Radiation Source Requirements	N/A	N/A
11.4.1.1	Laser Design and Operation in Compliance with ANSI Standard Z136.1-1993	N/A	N/A
11.4.1.2	Non-Ionizing Radiation	N/A	N/A
11.4.1.3	Safe Operation	N/A	N/A
11.4.1.4	Accidental Exposures	N/A	N/A
11.4.1.5	Laser and Optical Radiation Monitoring	N/A	N/A
11.4.2	Personnel Protection Devices	X	N/A
11.4.3	Inadvertent Adiabatic Combustion	X	N/A
12.0	Materials and Parts Interface Requirements		
12.1	Materials and Processes Use and Selection	X	3.11.1
12.1.1	Acceptance Criteria for Stress Corrosion Cracking	X	N/A
12.1.2	Hazardous Materials and Compatibility	X	N/A
12.1.2.1	Toxic Fuels and Toxic Combustion By-Products	X	N/A
12.1.3	Test and Acceptance Criteria for Flammability	X	N/A
12.1.3.1	High Oxygen Concentration Compatibility	X	N/A
12.1.4	Test and Acceptance Criteria for Toxic Offgassing (Toxicity)	X	N/A
12.1.5	Soot Production		
12.1.5.1	Soot Producing Experiments	X	N/A
12.1.5.1.1	Additional Containment	X	N/A
12.1.5.1.2	Soot Contingency Kit	X	N/A
12.1.5.2	Cleaning the CIR Combustion Chamber and Payload Components	X	N/A
12.2	Galvanic Corrosion	X	3.11.2-C
12.3	Fungus-Resistant Materials	X	3.11.4
12.4	Cleanliness	X	3.11.3
13.0	Fire Protection	**X**	N/A
13.1	Fire Event Prevention Requirements	X	3.10.1
13.2	Payload Parameter Monitoring	N/A	3.10.2.2.1

APPENDIX A ABBREVIATIONS AND ACRONYMS

Abbreviation or Acronym	Description
A	Amperes
AC	Alternating Current
ANSI	American National Standards Institute
API	Application Programming Interface
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ATCU	Air Thermal Control Unit
AWG	American Wire Gauge
°C	Degrees Celsius
C&W	Caution and Warning
CAN	Controller Area Network
CBP	CAN Bus Processor
CDS	Central Data System
cfm	Cubic Feet Per Minute
CG	Center of Gravity
CIR	Combustion Integrated Rack
cm	Centimeters
CO_2	Carbon Dioxide
COTS	Commercial Off-the-Shelf
CSCI	Computer Software Configuration Item
CSMA/CD	Carrier Sense Multiple Access with Collision Detection
CTBs	Cargo Transfer Bags
dB	Decibels
dBA	Acoustic decibels
DC	Direct Current
DCM	Diagnostic Control Module
DPIV	Digital Particle Imaging Velocimetry Package
ECS	Environmental Control System
EHS	Enhanced Huntsville Operations Support Center System
EIA	Electronics Industry Association
EMC	Electromagnetic Compatibility

Abbreviation or Acronym	Description
EMI	Electromagnetic Interference
EPCU	Electrical Power Control Unit
ES	Engineering and Science
ESD	Exploration Systems Division
ESN	External Services Network
EVP	Exhaust Vent Package
°F	Degrees Fahrenheit
FCF	Fluids and Combustion Facility
FCU	FOMA Control Unit
FIR	Fluids Integrated Rack
FDSS	Fire Detection and Suppression Subsystem
FLEX	Flame Extinguishment Experiment
FOMA	Fuel/Oxidizer Management Assembly
FRPC	Flexible Remote Power Controller
ft	Foot, feet
g	Gravity
GC	Gas Chromatograph
GFE	Government Furnished Equipment
GN_2	Gaseous Nitrogen
GPVP	Generic Payload Verification Plan
GRC	Glenn Research Center
GSE	Ground Support Equipment
GSP	Ground Support Personnel
GUI	Graphical User Interface
H&S	Health and Status
HOSC	Huntsville Operations Support Center
hr	Hour
HRDL	High Rate Data Link
Hz	Hertz
HTML	HyperText Markup Language
H_2O	Water
IA	Integration Agreement
ICD	Interface Control Document

Abbreviation or Acronym	Description
ICM	Illumination Control Module
IDD	Interface Definition Document
IEEE	Institute of Electrical and Electronic Engineers
in	Inches
I/O	Input/Output
IP	Internet Protocol
IPP	Image Processing Package
IPSU	Image Processing and Storage Unit
IPSU-A	Image Processing and Storage Unit - Analog
IR	Infrared
IRR	Interface Resource Ring
ISO	International Organization for Standards
ISPR	International Standard Payload Rack
ISS	International Space Station
ISSP	International Space Station Program
IVA	Intra-vehicular Activity
JSC	Johnson Space Center
kg	Kilograms
kN	kilo Newton
kilohm	kilo ohm(s)
kPa	Kilopascals
kW	Kilowatts
lb	Pounds
lb_f	Pounds Force
lb_m	Pounds Mass
LED	Light Emitting Diode
LLL	Low Light Level
LRDL	Low Rate Data Link
LSB	Least Significant Bit
m	Meters
mA	milliampere
MAPTIS	Materials and Processes Technical Information System
MDCA	Multi-User Droplet Combustion Apparatus

Abbreviation or Acronym	Description
MDL	Middeck Locker
MDK	Middeck
MDP	Maximum Design Pressure
Megohm	mega ohm
MHz	Megahertz
MIL	Military
MP	Main Processor
MPa	Mega Pascal
μA	Microamperes
μF	Microfarads
μm	Micrometers
MIL	Military
min	Minutes
mm	Millimeter
MPLM	Multi-Purpose Logistics Module
MRDL	Medium Rate Data Link
MRDOC	Microgravity Research, Development, and Operations Contract
ms	Milliseconds
MSFC	Marshall Space Flight Center
MTL	Moderate Temperature Loop
N	Newton
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NC	Noise Criteria
nm	Nanometer
NSTS	National Space Transportation System
ORU	Orbital Replacement Unit
OSAT	Office of Safety and Assurance Technologies
Pa	Pascals
PaRIS	Passive Rack Isolation System
PCI	Peripheral Component Interconnect
PD	Payload Developer
PDSS	Payload Data Services System

Abbreviation or Acronym	Description
PFE	Portable Fire Extinguisher
PI	Principal Investigator
PIL	Principal Investigator Location
PIRN	Preliminary Interface Revision Notice
POIC	Payload Operations Integration Center
PRCU	Payload Rack Checkout Unit
psi	Pounds per Square Inch
psia	Pounds per Square Inch Absolute
PSRP	Payload Safety Review Panel
PTFE	Polytetraflouroethylene
PWL	Sound Power Level
QD	Quick Disconnect
Ra	Rockwell Hardness
RF	Radio Frequency
RGB	Red Green Blue
RIF	Retractable Indexing Fiber
RS03	Electric Field Radiated Susceptibility
SCC	Stress Corrosion Cracking
scc	Standard Cubic Centimeters
sec	Second
SEDC	Sooting and Radiation Effects of Droplet Combustion
SEE	Single Event Effect
slpm	Standard Liter Per Minute
SPL	Sound Pressure Levels
SSC	Station Support Computer
SSP	Space Station/Shuttle Program
SVF	Soot Volume Fraction
TADS	Telemetry Acquisition and Display System
TBD	To Be Determined
TCP	Transmission Control Protocol
TRek	Telescience Resource Kit
TSC	Telescience Support Center
UDP	User Datagram Protocol

Abbreviation or Acronym	Description
UML	Universal Mounting Location
USL	U.S. Lab
UV	Ultraviolet
VDC	Voltage (Direct Current)
VES	Vacuum Exhaust System
V_{rms}	Voltage (Root Mean Square)
VSP	Video Switch Processor
W	Watt
WAN	Wide Area Network

APPENDIX B MDCA EXCEPTIONS

TABLE 53 MDCA EXCEPTIONS

Exception No.	ICD Section	Classification (1)	Description	Status
57217-NA-0007A	Section 11.0 (SSP 57000 Section No. 3.12.4.3.6)	Deviation	MDCA Connector Spacing	Approved by ISS
57217-NA-0010	Section 4.8.1 (SSP 57000 Section No. 3.1.1.3)	Exceedance	Crew Induced Loads	Approved by ISS
57217-NA-0028	Section 7.1.2 (SSP 57000 Section No. 3.2.4.5)	Waiver	ESD	Submitted to ISS 12/07/04
<TBD B-01>	Section 11.0 (SSP 57000 Section No. 3.12.4.3.13)	Exceedance	MDCA Pin Identification	Awaiting HFIT Inputs
FCF-ICD-CIR-MDCA-0001	Section 3.1.2.1	Deviation	MDCA Guide Pins at the PIL Mounting Holes	Approved by FCF
<TBD B-02>	Section 11.0 (SSP 57000 Section No. 3.12.6.3)	Deviation	Captive Parts	Will be handled through the HFIT process

Notes:

1. Exceedance, Deviation or Waiver

APPENDIX C LIST OF ITEMS TO BE DETERMINED

TABLE 54 TBD ITEMS

Identification Number	Description	Section	Date Available
02-01	The FCF Utilization Team to provide the FCF Software User's Manual after the document is written and released.	2.1.1	11/30/05
02-02	The FCF Utilization Team to provide the TADS-USER-003 document after it is written and released.	2.1.1	11/30/05
03-01	The FCF Utilization to provide the figure for the PI Port Envelope.	3.2.1.8.3 FIGURE 23	07/30/05
03-02	The FCF Utilization Team to provide CG data for the CIR HFR/HR Imaging Package when IAM rotated 180°.	3.8.2 TABLE 16	06/01/05
03-03	The FCF Utilization Team to provide CG data for the CIR HiBMS Imaging Package when IAM rotated 180°.	3.8.2 TABLE 16	06/01/05
05-01	The FCF Utilization Team to provide data on the pressure drop through the OHM.	5.4.6.1.3	06/01/05
08-01	The FCF Utilization Team to provide information for the Mass Data Storage Unit.	8.1.5	12/20/05
08-02	The FCF Utilization Team to determine how data management commands will be formatted and sent.	8.1.7.2.2	12/20/05
08-03	The FCF Utilization Team to provide a description of the header format.	8.1.7.2.3	07/20/05
B-01	The ISS Program Human Factors Implementation Team to provide final resolution on the MDCA Pin Identification Exception.	APPENDIX B TABLE 53	05/15/05
B-02	The ISS Program Human Factors Implementation Team to provide final resolution on the Captive Parts Exception.	APPENDIX B TABLE 53	05/15/05

APPENDIX D VXWORKS Kernel Configuration

This Appendix contains the VxWorks kernel configuration parameters that are created by the Tornado Project facility. This is a listing of the prjParams.h file.

```
/* prjParams.h - dynamically generated configuration header */

/*
GENERATED: Fri Oct 03 10:51:34 EDT 2003
DO NOT EDIT - file is regenerated whenever the project changes
*/

#ifndef INCprjParamsh
#define INCprjParamsh

/*** INCLUDED COMPONENTS ***/

#define INCLUDE_ANSI_ASSERT
#define INCLUDE_ANSI_CTYPE
#define INCLUDE_ANSI_LOCALE
#define INCLUDE_ANSI_MATH
#define INCLUDE_ANSI_STDIO
#define INCLUDE_ANSI_STDIO_EXTRA
#define INCLUDE_ANSI_STDLIB
#define INCLUDE_ANSI_STRING
#define INCLUDE_ANSI_TIME
#define INCLUDE_ARP_API
#define INCLUDE_AUX_CLK
#define INCLUDE_BOOTP
#define INCLUDE_BOOT_LINE_INIT
#define INCLUDE_BSD
#define INCLUDE_BSD_BOOT
#define INCLUDE_BSD_SOCKET
#define INCLUDE_BUF_MGR
#define INCLUDE_CACHE_ENABLE
#define INCLUDE_CACHE_SUPPORT
#define INCLUDE_CBIO
#define INCLUDE_CHIPS_69000
#define INCLUDE_CLASS_SHOW
#define INCLUDE_CPLUS
#define INCLUDE_CPLUS_COMPLEX
#define INCLUDE_CPLUS_COMPLEX_IO
#define INCLUDE_CPLUS_DEMANGLER
#define INCLUDE_CPLUS_IOSTREAMS
#define INCLUDE_CPLUS_IOSTREAMS_FULL
#define INCLUDE_CPLUS_IOSTREAMS_TEST
#define INCLUDE_CPLUS_STL
#define INCLUDE_CPLUS_STRING
```

```
#define INCLUDE_CPLUS_STRING_IO
#define INCLUDE_CPLUS_VXW
#define INCLUDE_DEBUG
#define INCLUDE_DHCPC_LEASE_CLEAN
#define INCLUDE_DISK_CACHE
#define INCLUDE_DISK_PART
#define INCLUDE_DISK_UTIL
#define INCLUDE_DLL
#define INCLUDE_DOSFS_CHKDSK
#define INCLUDE_DOSFS_DIR_VFAT
#define INCLUDE_DOSFS_FAT
#define INCLUDE_DOSFS_FMT
#define INCLUDE_DOSFS_MAIN
#define INCLUDE_END
#define INCLUDE_END_BOOT
#define INCLUDE_ENV_VARS
#define INCLUDE_EXC_HANDLING
#define INCLUDE_EXC_TASK
#define INCLUDE_FD
#define INCLUDE_FEI
#define INCLUDE_FLOATING_POINT
#define INCLUDE_FORMATTED_IO
#define INCLUDE_FTP_SERVER
#define INCLUDE_GS_IP_CARRIER
#define INCLUDE_HAMMERHEAD
#define INCLUDE_HASH
#define INCLUDE_HOST_TBL
#define INCLUDE_HPDI
#define INCLUDE_HW_FP
#define INCLUDE_HW_FP_SHOW
#define INCLUDE_ICMP
#define INCLUDE_IGMP
#define INCLUDE_IO_SYSTEM
#define INCLUDE_IP
#define INCLUDE_KERNEL
#define INCLUDE_LLA
#define INCLUDE_LM81
#define INCLUDE_LOADER
#define INCLUDE_LOGGING
#define INCLUDE_LOOPBACK
#define INCLUDE_LPT
#define INCLUDE_MAX1617
#define INCLUDE_MEI_MOTION_CTRL
#define INCLUDE_MEMORY_CONFIG
#define INCLUDE_MEM_MGR_BASIC
#define INCLUDE_MEM_MGR_FULL
#define INCLUDE_MEM_SHOW
```

```
#define INCLUDE_MMU_BASIC
#define INCLUDE_MODULE_MANAGER
#define INCLUDE_MSG_Q
#define INCLUDE_MSG_Q_SHOW
#define INCLUDE_MUX
#define INCLUDE_NETDEV_NAMEGET
#define INCLUDE_NETMASK_GET
#define INCLUDE_NETWORK
#define INCLUDE_NET_HOST_SETUP
#define INCLUDE_NET_INIT
#define INCLUDE_NET_LIB
#define INCLUDE_NET_REM_IO
#define INCLUDE_NET_SETUP
#define INCLUDE_NET_SHOW
#define INCLUDE_NFS
#define INCLUDE_NFS_SERVER
#define INCLUDE_OHCI
#define INCLUDE_PC_CONSOLE
#define INCLUDE_PING
#define INCLUDE_PIPES
#define INCLUDE_POSIX_AIO
#define INCLUDE_POSIX_AIO_SYSDRV
#define INCLUDE_POSIX_CLOCKS
#define INCLUDE_POSIX_FTRUNC
#define INCLUDE_POSIX_MEM
#define INCLUDE_POSIX_MQ
#define INCLUDE_POSIX_SCHED
#define INCLUDE_POSIX_SEM
#define INCLUDE_POSIX_SIGNALS
#define INCLUDE_POSIX_TIMERS
#define INCLUDE_PROG
#define INCLUDE_PXC2
#define INCLUDE_RAMDRV
#define INCLUDE_RLOGIN
#define INCLUDE_RNG_BUF
#define INCLUDE_RPC
#define INCLUDE_RTC146818
#define INCLUDE_SBS_PMCCAN
#define INCLUDE_SCSI
#define INCLUDE_SCSI2
#define INCLUDE_SELECT
#define INCLUDE_SEM_BINARY
#define INCLUDE_SEM_COUNTING
#define INCLUDE_SEM_MUTEX
#define INCLUDE_SEM_SHOW
#define INCLUDE_SHELL
#define INCLUDE_SHELL_BANNER
```

```
#define INCLUDE_SIGNALS
#define INCLUDE_SIO
#define INCLUDE_SPY
#define INCLUDE_STANDALONE_SYM_TBL
#define INCLUDE_STARTUP_SCRIPT
#define INCLUDE_STAT_SYM_TBL
#define INCLUDE_STDIO
#define INCLUDE_SYM_TBL
#define INCLUDE_SYM_TBL_INIT
#define INCLUDE_SYM_TBL_SHOW
#define INCLUDE_SYM_TBL_SYNC
#define INCLUDE_SYSCLK_INIT
#define INCLUDE_SYSHW_INIT
#define INCLUDE_SYS_START
#define INCLUDE_TAR
#define INCLUDE_TASK_HOOKS
#define INCLUDE_TASK_SHOW
#define INCLUDE_TASK_VARS
#define INCLUDE_TCP
#define INCLUDE_TCP_DEBUG
#define INCLUDE_TCP_SHOW
#define INCLUDE_TELNET
#define INCLUDE_TESTIT
#define INCLUDE_TFTP_CLIENT
#define INCLUDE_TIMESTAMP
#define INCLUDE_TIMEX
#define INCLUDE_TTY_DEV
#define INCLUDE_UDP
#define INCLUDE_UDP_SHOW
#define INCLUDE_UNLOADER
#define INCLUDE_USER_APPL
#define INCLUDE_VMIC_5790
#define INCLUDE_WATCHDOGS
#define INCLUDE_WATCHDOGS_SHOW
#define INCLUDE_WDB
#define INCLUDE_WDB_BANNER
#define INCLUDE_WDB_BP
#define INCLUDE_WDB_COMM_END
#define INCLUDE_WDB_CTXT
#define INCLUDE_WDB_DIRECT_CALL
#define INCLUDE_WDB_EVENTPOINTS
#define INCLUDE_WDB_EVENTS
#define INCLUDE_WDB_EXC_NOTIFY
#define INCLUDE_WDB_EXIT_NOTIFY
#define INCLUDE_WDB_FUNC_CALL
#define INCLUDE_WDB_GOPHER
#define INCLUDE_WDB_HW_FP
```

```
#define INCLUDE_WDB_MEM
#define INCLUDE_WDB_REG
#define INCLUDE_WDB_START_NOTIFY
#define INCLUDE_WDB_SYS
#define INCLUDE_WDB_SYS_HW_FP
#define INCLUDE_WDB_TASK
#define INCLUDE_WDB_TASK_BP
#define INCLUDE_WDB_TASK_HW_FP
#define INCLUDE_WDB_TSFS
#define INCLUDE_WDB_USER_EVENT
#define INCLUDE_WDB_VIO
#define INCLUDE_WDB_VIO_LIB
#define INSTALL_IEEE1394
#undef INCLUDE_PROTECT_TEXT
#undef INCLUDE_PROTECT_VEC_TABLE
#undef INCLUDE_PCI_PARAMS
#undef INCLUDE_VME_PARAMS
#undef INCLUDE_PCMCIA
#undef INCLUDE_TFFS
#undef INCLUDE_IDE
#undef INCLUDE_ATA
#undef INCLUDE_MMU_FULL
#undef INCLUDE_DOSFS
#undef INCLUDE_TYCODRV_5_2
#undef INCLUDE_SW_FP
#undef INCLUDE_DC
#undef INCLUDE_EGL
#undef INCLUDE_EI
#undef INCLUDE_EX
#undef INCLUDE_ENP
#undef INCLUDE_IE
#undef INCLUDE_ILAC
#undef INCLUDE_LN
#undef INCLUDE_LNSGI
#undef INCLUDE_NIC
#undef INCLUDE_NIC_EVB
#undef INCLUDE_MED
#undef INCLUDE_ELC
#undef INCLUDE_ULTRA
#undef INCLUDE_EEX
#undef INCLUDE_ELT
#undef INCLUDE_QU
#undef INCLUDE_ENE
#undef INCLUDE_ESMC
#undef INCLUDE_SN
#undef INCLUDE_OLI
#undef INCLUDE_USR_ENTRIES
```

```
#undef INCLUDE_IF_USR
#undef INCLUDE_LNEBSA
#undef INCLUDE_FN
#undef INCLUDE_ZBUF_SOCK
#undef INCLUDE_PPP
#undef INCLUDE_PPP_BOOT
#undef INCLUDE_PPP_CRYPT
#undef INCLUDE_SLIP
#undef INCLUDE_SLIP_BOOT
#undef INCLUDE_OSPF
#undef INCLUDE_RIP
#undef INCLUDE_ROUTE_SOCK
#undef INCLUDE_DNS_RESOLVER
#undef INCLUDE_DHCPC
#undef INCLUDE_DHCPR
#undef INCLUDE_DHCPS
#undef INCLUDE_SNTPC
#undef INCLUDE_SNTPS
#undef INCLUDE_SECURITY
#undef INCLUDE_HTTP
#undef INCLUDE_FTPD_SECURITY
#undef INCLUDE_NFS_MOUNT_ALL
#undef INCLUDE_TFTP_SERVER
#undef INCLUDE_IP_FILTER
#undef BSD43_COMPATIBLE
#undef INCLUDE_MCAST_ROUTING
#undef INCLUDE_STREAMS
#undef INCLUDE_STREAMS_ALL
#undef INCLUDE_STREAMS_AUTOPUSH
#undef INCLUDE_STREAMS_DEBUG
#undef INCLUDE_STREAMS_DLPI
#undef INCLUDE_STREAMS_SOCKET
#undef INCLUDE_STREAMS_STRACE
#undef INCLUDE_STREAMS_STRERR
#undef INCLUDE_STREAMS_TLI
#undef INCLUDE_PROXY_CLIENT
#undef INCLUDE_PROXY_DEFAULT_ADDR
#undef INCLUDE_PROXY_SERVER
#undef INCLUDE_SM_NET_ADDRGET
#undef INCLUDE_SECOND_SMNET
#undef INCLUDE_SM_NET
#undef INCLUDE_SM_SEQ_ADDR
#undef INCLUDE_MIB2_ALL
#undef INCLUDE_MIB2_AT
#undef INCLUDE_MIB2_ICMP
#undef INCLUDE_MIB2_IF
#undef INCLUDE_MIB2_IP
```

```
#undef INCLUDE_MIB2_SYSTEM
#undef INCLUDE_MIB2_TCP
#undef INCLUDE_MIB2_UDP
#undef INCLUDE_SNMPD
#undef INCLUDE_DHCPC_SHOW
#undef INCLUDE_ICMP_SHOW
#undef INCLUDE_IGMP_SHOW
#undef INCLUDE_SM_NET_SHOW
#undef INCLUDE_DHCPC_LEASE_TEST
#undef INCLUDE_DEFER_NET_INIT
#undef INCLUDE_DHCPC_LEASE_GET
#undef INCLUDE_CPLUS_TOOLS
#undef INCLUDE_MMU_FULL_SHOW
#undef INCLUDE_POSIX_AIO_SHOW
#undef INCLUDE_POSIX_MQ_SHOW
#undef INCLUDE_POSIX_SEM_SHOW
#undef INCLUDE_STDIO_SHOW
#undef INCLUDE_TASK_HOOKS_SHOW
#undef INCLUDE_TRIGGER_SHOW
#undef INCLUDE_RBUFF_SHOW
#undef INCLUDE_ATA_SHOW
#undef INCLUDE_TRIGGERING
#undef INCLUDE_RBUFF
#undef INCLUDE_CODETEST
#undef INCLUDE_NET_SYM_TBL
#undef INCLUDE_WDB_COMM_SERIAL
#undef INCLUDE_WDB_COMM_TYCODRV_5_2
#undef INCLUDE_WDB_COMM_NETWORK
#undef INCLUDE_WDB_COMM_NETROM
#undef INCLUDE_WDB_COMM_CUSTOM
#undef INCLUDE_WDB_COMM_PIPE
#undef INCLUDE_SM_OBJ
#undef INCLUDE_RT11FS
#undef INCLUDE_RAWFS
#undef INCLUDE_WINDVIEW
#undef INCLUDE_WINDVIEW_CLASS
#undef INCLUDE_WVUPLOAD_FILE
#undef INCLUDE_WVUPLOAD_SOCK
#undef INCLUDE_WVUPLOAD_TSFSSOCK
#undef INCLUDE_SYS_TIMESTAMP
#undef INCLUDE_USER_TIMESTAMP
#undef INCLUDE_SEQ_TIMESTAMP
#undef INCLUDE_WV_BUFF_USER
#undef INCLUDE_DOSFS_DIR_FIXED
#undef INCLUDE_RAM_DISK
#undef INCLUDE_IEEE1394_JOBHANDLER
#undef INCLUDE_LPBK
```

```
#undef INCLUDE_PWSAVE
#undef INCLUDE_RACKNET_END
#undef INCLUDE_RACKNET_END2
#undef INCLUDE_RACKNET_SHOW

/*** PARAMETERS ***/

#undef  LOCAL_MEM_LOCAL_ADRS
#define LOCAL_MEM_LOCAL_ADRS 0x00000000
#undef  LOCAL_MEM_SIZE
#define LOCAL_MEM_SIZE 0x00800000
#undef  LOCAL_MEM_AUTOSIZE
#define LOCAL_MEM_AUTOSIZE
#undef  USER_RESERVED_MEM
#define USER_RESERVED_MEM 0
#undef  NV_RAM_SIZE
#define NV_RAM_SIZE 292
#undef  NV_BOOT_OFFSET
#define NV_BOOT_OFFSET 0
#undef  VEC_BASE_ADRS
#define VEC_BASE_ADRS ((char *) LOCAL_MEM_LOCAL_ADRS)
#undef  EXC_MSG_OFFSET
#define EXC_MSG_OFFSET 0x1300
#undef  EXC_MSG_ADRS
#define EXC_MSG_ADRS ((char *)
(LOCAL_MEM_LOCAL_ADRS+EXC_MSG_OFFSET))
#undef  BOOT_LINE_SIZE
#define BOOT_LINE_SIZE 255
#undef  BOOT_LINE_ADRS
#define BOOT_LINE_ADRS ((char *)
(LOCAL_MEM_LOCAL_ADRS+BOOT_LINE_OFFSET))
#undef  BOOT_LINE_OFFSET
#define BOOT_LINE_OFFSET 0x1200
#undef  DEFAULT_BOOT_LINE
#define DEFAULT_BOOT_LINE ""
#undef  RESERVED
#define RESERVED 0
#undef  FREE_RAM_ADRS
#define FREE_RAM_ADRS (end)
#undef  ROM_WARM_ADRS
#define ROM_WARM_ADRS ("unused")
#undef  STACK_SAVE
#define STACK_SAVE 0x40
#undef  USER_I_CACHE_MODE
#define USER_I_CACHE_MODE CACHE_WRITETHROUGH
#undef  USER_D_CACHE_MODE
#define USER_D_CACHE_MODE CACHE_COPYBACK
```

```
#undef  USER_I_CACHE_ENABLE
#define USER_I_CACHE_ENABLE
#undef  USER_D_CACHE_ENABLE
#define USER_D_CACHE_ENABLE
#undef  LPT_CHANNELS
#define LPT_CHANNELS 1
#undef  FD_INT_VEC
#define FD_INT_VEC (INT_VEC_GET (FD_INT_LVL))
#undef  FD_INT_LVL
#define FD_INT_LVL 0x06
#undef  SYS_CLK_RATE
#define SYS_CLK_RATE 60
#undef  SYS_CLK_RATE_MIN
#define SYS_CLK_RATE_MIN 19
#undef  SYS_CLK_RATE_MAX
#define SYS_CLK_RATE_MAX (PIT_CLOCK/256)
#undef  AUX_CLK_RATE_MIN
#define AUX_CLK_RATE_MIN 2
#undef  AUX_CLK_RATE_MAX
#define AUX_CLK_RATE_MAX 8192
#undef  NUM_TTY
#define NUM_TTY (N_UART_CHANNELS)
#undef  CONSOLE_TTY
#define CONSOLE_TTY -1
#undef  CONSOLE_BAUD_RATE
#define CONSOLE_BAUD_RATE 9600
#undef  N_VIRTUAL_CONSOLES
#define N_VIRTUAL_CONSOLES 2
#undef  PC_CONSOLE
#define PC_CONSOLE 0
#undef  FEI_POOL_ADRS
#define FEI_POOL_ADRS NONE
#undef  IP_FLAGS_DFLT
#define IP_FLAGS_DFLT (IP_DO_FORWARDING | IP_DO_REDIRECT |
IP_DO_CHECKSUM_SND | IP_DO_CHECKSUM_RCV)
#undef  IP_TTL_DFLT
#define IP_TTL_DFLT 64
#undef  IP_QLEN_DFLT
#define IP_QLEN_DFLT 50
#undef  IP_FRAG_TTL_DFLT
#define IP_FRAG_TTL_DFLT 60
#undef  ICMP_FLAGS_DFLT
#define ICMP_FLAGS_DFLT (ICMP_NO_MASK_REPLY)
#undef  UDP_FLAGS_DFLT
#define UDP_FLAGS_DFLT (UDP_DO_CKSUM_SND | UDP_DO_CKSUM_RCV)
#undef  UDP_SND_SIZE_DFLT
#define UDP_SND_SIZE_DFLT 9216
```

```
#undef  UDP_RCV_SIZE_DFLT
#define UDP_RCV_SIZE_DFLT 41600
#undef  TCP_FLAGS_DFLT
#define TCP_FLAGS_DFLT (TCP_DO_RFC1323)
#undef  TCP_SND_SIZE_DFLT
#define TCP_SND_SIZE_DFLT 8192
#undef  TCP_RCV_SIZE_DFLT
#define TCP_RCV_SIZE_DFLT 8192
#undef  TCP_CON_TIMEO_DFLT
#define TCP_CON_TIMEO_DFLT 150
#undef  TCP_REXMT_THLD_DFLT
#define TCP_REXMT_THLD_DFLT 3
#undef  TCP_MSS_DFLT
#define TCP_MSS_DFLT 512
#undef  TCP_RND_TRIP_DFLT
#define TCP_RND_TRIP_DFLT 3
#undef  TCP_IDLE_TIMEO_DFLT
#define TCP_IDLE_TIMEO_DFLT 14400
#undef  TCP_MAX_PROBE_DFLT
#define TCP_MAX_PROBE_DFLT 8
#undef  NUM_FILES
#define NUM_FILES 1000
#undef  NFS_USER_ID
#define NFS_USER_ID 2001
#undef  NFS_GROUP_ID
#define NFS_GROUP_ID 100
#undef  NUM_NET_MBLKS
#define NUM_NET_MBLKS 400
#undef  NUM_CL_BLKS
#define NUM_CL_BLKS (NUM_64 + NUM_128 + NUM_256 + NUM_512 + NUM_1024
+
NUM_2048)
#undef  NUM_64
#define NUM_64 100
#undef  NUM_128
#define NUM_128 100
#undef  NUM_256
#define NUM_256 40
#undef  NUM_512
#define NUM_512 40
#undef  NUM_1024
#define NUM_1024 25
#undef  NUM_2048
#define NUM_2048 25
#undef  NUM_SYS_MBLKS
#define NUM_SYS_MBLKS (2 * NUM_SYS_CL_BLKS)
#undef  NUM_SYS_CL_BLKS
```

```
#define NUM_SYS_CL_BLKS (NUM_SYS_64  + NUM_SYS_128 + NUM_SYS_256 +
NUM_SYS_512)
#undef  NUM_SYS_64
#define NUM_SYS_64 64
#undef  NUM_SYS_128
#define NUM_SYS_128 64
#undef  NUM_SYS_256
#define NUM_SYS_256 64
#undef  NUM_SYS_512
#define NUM_SYS_512 64
#undef  IP_MAX_UNITS
#define IP_MAX_UNITS 4
#undef  CLEAR_BSS
#define CLEAR_BSS
#undef  MAX_LIO_CALLS
#define MAX_LIO_CALLS 0
#undef  MAX_AIO_SYS_TASKS
#define MAX_AIO_SYS_TASKS 0
#undef  AIO_TASK_PRIORITY
#define AIO_TASK_PRIORITY 0
#undef  AIO_TASK_STACK_SIZE
#define AIO_TASK_STACK_SIZE 0
#undef  MQ_HASH_SIZE
#define MQ_HASH_SIZE 0
#undef  NUM_SIGNAL_QUEUES
#define NUM_SIGNAL_QUEUES 16
#undef  SHELL_STACK_SIZE
#define SHELL_STACK_SIZE 10000
#undef  SYM_TBL_HASH_SIZE_LOG2
#define SYM_TBL_HASH_SIZE_LOG2 8
#undef  STAT_TBL_HASH_SIZE_LOG2
#define STAT_TBL_HASH_SIZE_LOG2 6
#undef  WDB_STACK_SIZE
#define WDB_STACK_SIZE 0x1000
#undef  WDB_BP_MAX
#define WDB_BP_MAX 50
#undef  WDB_SPAWN_PRI
#define WDB_SPAWN_PRI 100
#undef  WDB_SPAWN_OPTS
#define WDB_SPAWN_OPTS VX_FP_TASK
#undef  WDB_TASK_PRIORITY
#define WDB_TASK_PRIORITY 3
#undef  WDB_TASK_OPTIONS
#define WDB_TASK_OPTIONS VX_UNBREAKABLE | VX_FP_TASK
#undef  WDB_RESTART_TIME
#define WDB_RESTART_TIME 10
#undef  WDB_MAX_RESTARTS
```

```
#define WDB_MAX_RESTARTS 5
#undef  INCLUDE_CONSTANT_RDY_Q
#define INCLUDE_CONSTANT_RDY_Q
#undef  ROOT_STACK_SIZE
#define ROOT_STACK_SIZE 10000
#undef  ISR_STACK_SIZE
#define ISR_STACK_SIZE 1000
#undef  INT_LOCK_LEVEL
#define INT_LOCK_LEVEL 0x0
#undef  ENV_VAR_USE_HOOKS
#define ENV_VAR_USE_HOOKS TRUE
#undef  NUM_DRIVERS
#define NUM_DRIVERS 20
#undef  MAX_LOG_MSGS
#define MAX_LOG_MSGS 50
#undef  FD_DEV_NAME
#define FD_DEV_NAME "/fd"
#undef  FD_CACHE_SIZE
#define FD_CACHE_SIZE (128*1024)
#undef  FD_0_TYPE
#define FD_0_TYPE 0
#undef  FD_1_TYPE
#define FD_1_TYPE NONE
#undef  OHCI_DESC_POOLS_LENGTH
#define OHCI_DESC_POOLS_LENGTH 16
#undef  OHCI_CYCLE_CLOCK_ACC
#define OHCI_CYCLE_CLOCK_ACC 50
#undef  OHCI_MAX_REQ
#define OHCI_MAX_REQ 13
#undef  OHCI_MIN_NB_OF_DESC
#define OHCI_MIN_NB_OF_DESC 3
#undef  OHCI_SPAWN_POOL_LENGTH
#define OHCI_SPAWN_POOL_LENGTH 3
#undef  OHCI_POSTED_WR_ENABLE
#define OHCI_POSTED_WR_ENABLE false
#undef  OHCI_MCP750_PATCH_ENABLE
#define OHCI_MCP750_PATCH_ENABLE false
#undef  OHCI_USE_CACHE_SAFE_MEM
#define OHCI_USE_CACHE_SAFE_MEM false
#undef  OHCI_TASK_HANDLER_PRIORITY
#define OHCI_TASK_HANDLER_PRIORITY 215
#undef  OHCI_MAX_INT_MISSED_RETRY
#define OHCI_MAX_INT_MISSED_RETRY 3

#endif /* INCprjParamsh */
```